LSO-000-286-1410

LIQUID ROCKET BOOSTER INTEGRATION STUDY

VOLUME III OF V
STUDY PRODUCTS
PART 1
SECTIONS 1-7

KENNEDY SPACE CENTER
NAS10-11475

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LRBI FINAL REPORT
CONTENTS GUIDE

VOLUME I - EXECUTIVE SUMMARY

VOLUME II - STUDY SUMMARY

SECTION 1: LRBI Study Synopsis - An assessment of the study objectives, approach, analysis, and rationale. The study findings and major conclusions are presented.

SECTION 2: Launch Site Plan - An implementation plan for the KSC launch site integration of LRB ground processing. The plan includes details in the areas of facility activations, operational schedules, costs, manpower, safety and environmental aspects.

SECTION 3: Ground Operations Cost Model (GOCM) - The updating and enhancement of this NASA provided computer-based costing model are described. Its application to LRB integration and instructions for modification and expanded use are presented.

SECTION 4: Cost - Summary and Analysis of KSC Costs.

VOLUME III - STUDY PRODUCTS

The study output has been developed in the form of nineteen derived study products. These are presented and described in the subsections of this volume.

VOLUME IV - REVIEWS AND PRESENTATIONS

The progress reviews and oral presentations prepared during the course of the study are presented here along with facing page text where available.

VOLUME V - APPENDICES

Study supporting data used or referenced during the study effort are presented and indexed to the corresponding study products.

LIST OF ABBREVIATIONS AND ACRONYMS

ADP	Automatic Data Processing
A&E	Architectual and Engineering
AF	Air Force
AI	Artificial Intelligence
AL	Aluminum
AL-Li	Aluminum Lithium Alloy
ALS	Advanced Launch Systems
ALT	Alternate
AOA	Abort Once Around
AOPL	Advanced Order Parts List
AP	Auxiliary Platform
APU	Auxiliary Power Unit
ARF	Assembly and Refurbishment Facility
ARTEMIS	Accounting, Reporting, Tracking, & Evaluation Management - Information System
ASRM	Advanced Solid Rocket Motor
ASSY	Assembly
ATO	Abort to Orbit
ATP	Authority to Proceed
AUTO	Automatic
AWCS	Automated Work Control System
BITE	Built-in Test Equipment
BLOW	Booster Liftoff Weight
BOC	Base Operations Contractor
BSM	Booster Separation Motor

C	Celsius
CAD	Computer Aided Design
CALS	Computer Aided Logistics System
CCAFS	Cape Canaveral Air Force Station
CCB	Change Control Board
CCC	Complex Control Center
CCF	Compressor Converter Facility
CCMS	Checkout, Control and Monitor Subsystem
CDDT	Countdown Demonstration Test
CDR	Critical Design Review
CEC	Core Electronics Contractor
CER	Cost Estimating Relationships
CG	Center of Gravity
CH4	Methane
CITE	Cargo Integration Test Equipment
CM	Construction Management
	Configuration Management
C/O	Closeout
	Checkout
CONC	Concrete
C of F	Cost of Facilities
COMM	Communications
CPF	Cost per Foot
CPF2	Cost per Square Foot
CPF3	Cost per Cubic Foot
CPM	Critical Path Management
CPU	Central Processing Unit
CR	Control Room
Cryo	Cryogenic
C/S	Contractor Support
CT	Crawler Transporter
CY	Calendar Year

dBase	Data Base - Software Program
dc	Direct Current
DDS	Data Processing System
DDT&E	Design, Development, Test & Engineering
DE	Design Engineering
DEQ	Direct Equivalent Head Count
DFRF	Dryden Flight Research Facility
DFI	Development Flight Instrumentation
DHC	Direct Head Count
DIST	Distributor
DOD	Department of Defense
DOS	Disk Operating System
DOT	Department of Transportation
ECLSS	Environmental Control & Life Support System
ECS	Environmental Control System
EL	Elevation
ELS	Eastern Launch Site
ELV	Expendable Launch Vehicle
EMA	Electrical Mechanical Actuator
EMERG	Emergency
EPA	Environmental Protection Agency
EPDC	Electrical Power and Distribution Control
EPL	Emergency Power Level
ET	External Tank
ET-HPF	External Tanks - Horizontal Processing Facility
ETR	Eastern Test Range
F	Fahrenheit
FAA	Federal Aviation Administration
F&D	Fill & Drain
FEP	Front End Processor
FLT	Flight

FMEA/CIL	Failures Modes & Effects Analysis/Critical Items List
FRF	Flight Readiness Firing
FRSC	Forward Reaction Control System
ft	Feet
FSS	Fixed Service Structure
FWD	Forward
FY	Fiscal Year

G&A	General and Administrative
G,g	Acceleration of Gravity
GAL	Gallons
GDSS(GD)	General Dynamics Space Systems
GEN	Generator
GFE	Government Furnished Equipment
GH2	Gaseous Hydrogen
GHe	Gaseous Helium
GLOW	Gross Liftoff Weight
GLS	Ground Launch Sequencer
GN2	Gaseous Nitrogen
GN&C	Guidance, Navigation & Control
GOAL	Ground Operations Aerospace Language
GOX	Gaseous Oxygen
GOCM	Ground Operations Cost Model
GPC	General Purpose Computer
GPM	Gallons Per Minute
GRD	Ground
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
GTSI	Grumman Technical Services, Inc.
GUCP	Ground Umbilical Carrier Plate

H2	Hydrogen
HAZGAS	Hazardous Gas
HB	High Bay
HDP	Holddown Post
He	Helium
HIM	Hardware Interface Module
HMF	Hypergolics Maintenance Facility
HPF	Horizontal Processing Facility
HQ	Headquarters
HVAC	Heating, Ventilation, and Air Conditioning
HW	Hardware
HYD	Hydraulic(s)
HYPER	Hypergolic
Hz	Hertz
IBM	International Business Machines
ICD	Interface Control Document
I/F	Interface
ILC	Initial Launch Capability
INST	Instrumentation
INTEG	Integration
IOC	Initial Operational Capability
IPR	Interum Problem Report
IRD	Interface Requirements Document
IUS	Interial Upper Stage
JSC	Johnson Space Center

K	Thousands
K	Kelvin
KLB	Thousands of Pounds
KSC	Kennedy Space Center
KW	Kilowatt
LAC	Launch Accessories Contractor
LC-39	Launch Complex 39
LCC	Life Cycle Cost
LCC	Launch Control Center
LCH4	Liquid Methane
LESC	Lockheed Engineering and Science Company
LETF	Launch Equipment Test Facility
LEO	Low Earth Orbit
LH2	Liquid Hydrogen
Li	Lithium
LN2	Liquid Nitrogen
LNG	Liquid Natural Gas
LO2	Liquid Oxygen
LOX	Liquid Oxygen
LPS	Launch Processing System
LRB	Liquid Rocket Booster
LRB-HPF	Liquid Rocket Booster Horizontal Processing Facility
LRBI	Liquid Rocket Booster Integration
LRU	Line Replaceable Unit
LSE	Launch Support Equipment
LSOC	Lockheed Space Operations Company
LUT	Launcher Umbilical Tower
MAX	Maximum
MECO	Main Engine Cutoff
MDAC	McDonnell Douglas Astronautics Company
MIL	Military

MIN	Minimum
MLP	Mobile Launch Platform
MMC	Martin-Marietta Corporation
MMH	Mono Methyl Hydrazine
MOD	Mission Operations Directorate
MOU	Memorandum of Understanding
MP	Manpower
MPS	Main Propulsion System
MSBLS	Microwave Scanning Beam Landing System
MSFC	Marshall Space Flight Center
MST	Mobile Service Tower
MTI	MortonThiokol, Inc.

N2	Nitrogen
NASA	National Aeronautics and Space Administration
NDE	Non-Destructive Evaluation
NDT	Non-Destructive Test
NF	Nose Fairing
N2O2	Nitrogen Tetroxide
NPL	Nominal Power Level
NPSH	Not positive Suction Head
NRC	National Research Council
NSTL	National Space Technology Laboratories (Stennis Space Center)
NSTS	National Space Transportation System
NWS	National Weather Service

OAA	Orbiter Access Arm
OIS	Operational Intercommunications System
OJT	On-the-job Training
O&M	Operations and Maintenance
OMD	Operating and Maintenance Documentation

OMI	Operations and Maintenance Instruction
OMRF	Orbiter Maintenance and Refurbishment Facility
OMRSD	Operational Maintenance Requirements and Specifications Document
OMS	Orbital Maneuvering System
OPF	Orbiter Processing Facility
OPS	Operations
OMBUU	Orbiter Mid Body Umbilical Unit
ORB	Orbiter
ORD	Operational Readiness Date
ORI	Operational Readiness Inspection
OSHA	Occupational Safety & Health Administration
OTV	Operational Television

PA	Public Affairs
PAWS	Pan Am World Services, Inc.
P/A	Propulsion/Avionics Module
Pc	Engine Combustion Chamber Pressure
PC	Personal Computer
PCM	Pulse Code Modulator
PCR	Payload Changeout Room
PDR	Preliminary Design Review
PER	Preliminary Engineering Report
PGHM	Payload Ground Handling Mechanism
PIC	Pyro Initiator Controller
PIF	Payload Integration Facility
P/L	Payload
PMM	Program Model Number
PMS	Permanent Measuring System
PO	Purchase Order
POP	Programs Operations Plan
PR	Problem Report
PRACA	Problem Reporting and Corrective Action
PRCBD	Program Review Control Board Directive

PRC	Planning Research Corporation
PRD	Program Requirements Document
PRESS	Pressure, pressurization
PROP	Propellant
PRR	Preliminary Requirements Review
PSI	Pounds Per Square Inch
psia	Pounds Per Square Inch Absolute
psig	Pounds Per Square Inch Gage
PSP	Process Support Plan
PT&I	Payroll Taxes and Insurance
P&W	Pratt & Whitney Company

Q	Dynamic Pressure
QA	Quality Assurance
Q-Alpha	Dynamic Pressure x Angle of Attack
QC	Quality Control
QD	Quick Disconnect
QTY	Quantity

R	Ranking
RAM	Random Access Memory
RCS	Reaction Control System
R&D	Research and Development
RF	Radio Frequency
RFP	Request for Proposal
RIC	Rockwell International Corporation
ROM	Rough Order of Magnitute
RP-1	Propellant (Kerosene Related Petroleum Product)
RPL	Rated Power Level
RPS	Record and Playback System
RPSF	Rotation, Processing & Surge Facility

R/R	Remove/Replace
RSLS	Redundant Set Launch Sequencer
RSS	Rotating Service Structure
R&T	Research and Technology
RTLS	Return to Launch Site

SAIL	Shuttle Avionics Integration Laboratory
SAB	Shuttle Assembly Building
SCAPE	Self-Contained Atmospheric Protective Ensemble
SDI	Strategic Defense Initiative
SDV	Shuttle Derivative Vehicle
SEB	Source Evaluation Board
SEC	Second(s), Secondary
SGOS	Shuttle Ground Operations Simulator
SIES	Supervision, Inspection & Engineering Services
SIT	Shuttle Integrated Test
	System Integrated Test
SLC-6	Shuttle Launch Complex No.6
SLF	Shuttle Landing Facility
SOFI	Spray On Foam Insulation
SOW	Statement of Work
SPC	Shuttle Processing Contractor
SPF	Software Production Facility
SPDMS	Shuttle Processing Data Management System
SRB	Solid Rocket Booster
SRM	Solid Rocket Motor
SRSS	Shuttle Range Safety System
SR&QA	Safety, Reliability and Quality Assurance
SSC	Stennis Space Center (NSTL)
SSME	Space Shuttle Main Engine
SSV	Space Shuttle Vehicle
STD	Standard
STS	Space Transportation System

SUBSTA	Substation
SW	Switch
S/W	Software

TAL	Transatlantic Landing
TBD	To Be Determined
T&C/O	Test and Checkout
TFER	Transfer
T-0	Liftoff Time
TOPS	Technical Operating Procedures
TPS	Thermal Protection System
TSM	Tail Service Mast
TTV	Termination/Test/Verification
TVA	Thrust Vector Activator
TVC	Thrust Vector Control
T/W	Thrust to Weight Ratio
TYP	Typical

ULCE	Unified Life Cycle Engineering
UMB	Umbilical
UPS	Unintegrated Power System
USAF	United States Air Force
USS	Utility Substation

V	Volt(s)
VAB	Vehicle Assembly Building
VAFB	Vandenberg Air Force Base
VIB	Vertical Integration Building
VLS	Vandenberg Launch Site
VPF	Vertical Processing Facility

WAD	Work Authorization Document
WBS	Work Breakdown Structure
WIP	Work in Progress
WSMR	White Sands Missile Range
WTR	Western Test Range

VOLUME III

SECTION 1

LRB GROUND OPERATIONS PLAN

VOLUME III SECTION 1

GROUND OPERATIONS PLAN

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GROUND OPERATIONS PLAN

The Phase-A Ground Operations Plan is a standalone study document, similar in format to a typical and preliminary Station Set Requirements/Specifications document.

The Ground Operations Plan identifies the unique LRB parameters which influence and dictate the final station set configurations. These include the Flight Element specifications, Ground Processing requirements and other Interface requirements. Volume III Sections 3, 4, and 5 of this report present the station set concepts in detail for the facility requirements, Launch Support Equipment (LSE) and Ground Support Equipment (GSE) respectively.

The station set implementation plans are displayed in this section and are accompanied with a discussion of proposed conceptual methods and techniques for end-to-end implementation at the launch site project office level.

A brief summary of implementation resource requirements are presented. This includes the cost impacts by station set and the program level manpower impacts associated with the LRB activation management.

1.1 LRB STATION SETS

A station set, as defined in the National Space Transportation System (NSTS) Document 07700 Volume IX is "an accumulation of facilities, support equipment and software required to support a specific function". This results in a series of "ground system design solutions".

The LRB station set definition is consistent with the NSTS. The Phase-A conceptual application is to insure integration of the LRB flight element specifications, ground processing requirements and other interface requirements into compatible ground system design solutions.

Figure 1.1 displays the station sets impacted by integration of the LRB at the launch sites. These station sets can be distinguished geographical, as the VAB is, or functional, like the LRB Engine Shop. As a result of the multiple LRB scenario evaluations and subsequent impact analysis per-

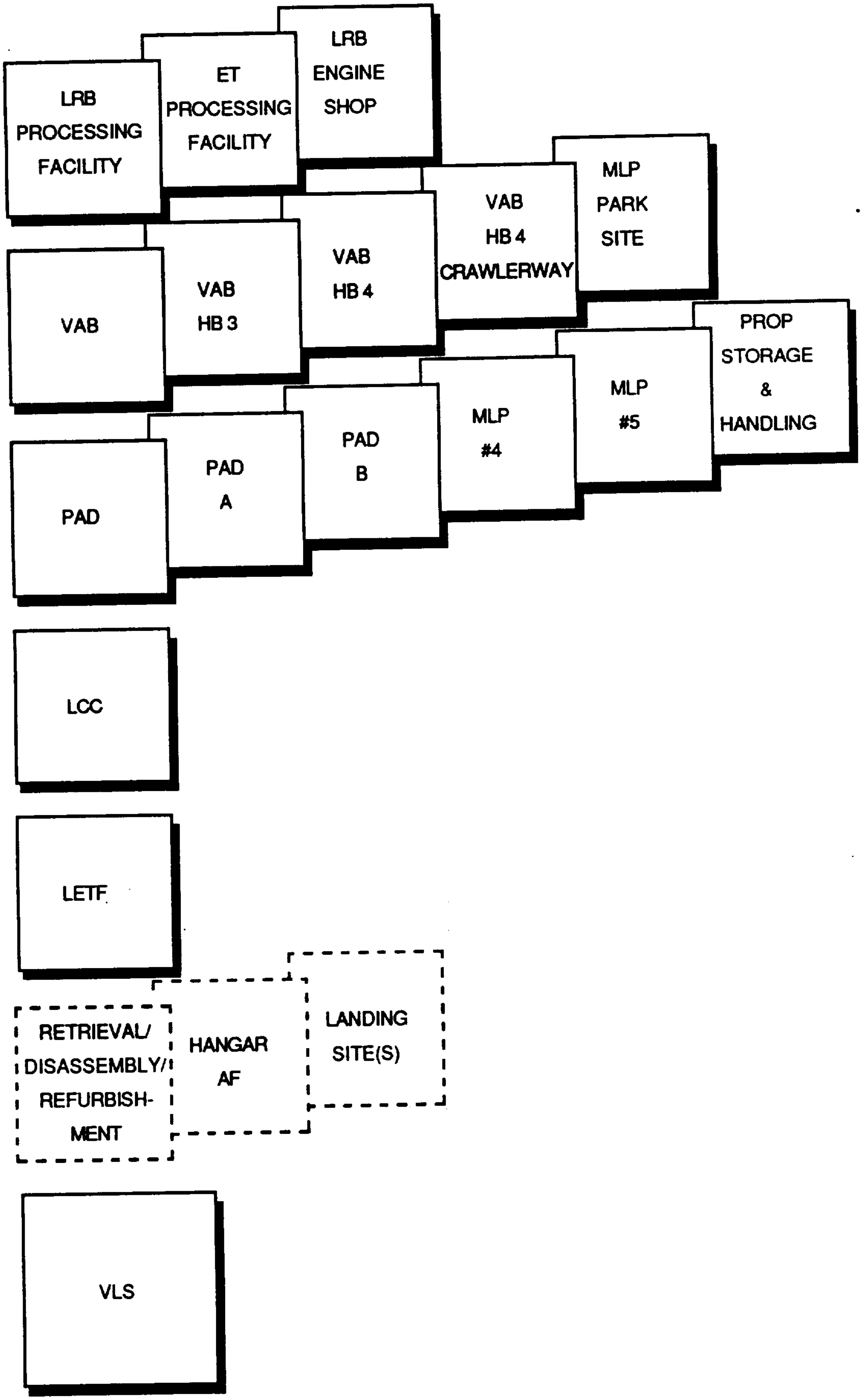


Figure 1.1. LRB Station Sets.

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formed, conclusions have been made in providing new capability, such as the ET/LRB Horizontal Processing facility, or modifying existing capability, such as LC-39 Pads A and B.

1.2 FLIGHT ELEMENT SPECIFICATIONS

The final configuration of each LRB station set is dependent upon the flight element specifications. These vehicle characteristics will influence the design solutions for the facility requirements, LSE, GSE and ground operations software.

The flight element to ground systems specifications are baselined and levied as launch and landing site requirements during Phase C/D by the Interface Control Documents (ICD) and the Operations and Maintenance Requirements Specifications (OMRS).

Figures 1.2-1 through 1.2-4 display examples of the LRB flight element specifications for the LRB processing facility, VAB, LRB MLP and the Pad. These are generic in detail and consistent with the level of trade studies performed by the MSFC Phase-A contractors.

1.3 GROUND PROCESSING REQUIREMENTS

The Ground Processing Requirements in combination with the flight element specifications dictate the station set design solutions.The launch and landing site station sets must provide, as a minimum, the functional capability for:

- Operational checkout
- Systems Verification
- Maintenance
  - Contingency
  - Scheduled
- Line replaceable unit (LRU)
  - Fault isolation
  - Removal/replacement
  - Verification
- Integrated testing
- Launch
- Landing

FLIGHT ELEMENT SPECIFICATION	STATION SET CONFIGURATION*
• LENGTH	• FACILITY DIMENSIONS • APRON DIMENSIONS
• DIAMETER	• FACILITY DIMENSIONS • APRON DIMENSIONS
• WEIGHT	• TOW WAY ROUTES

Figure 1.2-1. LRB Processing Facility Flight Element Specifications

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FLIGHT ELEMENT SPECIFICATION	STATION SET CONFIGURATION*
• AFT SKIRT	• ACCESS PLATFORMS • ECS
• INTERTANK	• ACCESS PLATFORMS • ECS
• NOSE FAIRING	• ACCESS PLATFORMS • ECS
• STIFFNESS	• NO STRONGBACKS

* STATION SET CONFIGURATION AS A FUNCTION DERIVED FROM THE FLIGHT ELEMENT SPECIFICATION

Figure 1.2-2. VAB Flight Element Specifications

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FLIGHT ELEMENT SPECIFICATION	STATION SET CONFIGURATION*
• AFT SKIRT DIAMETER	• EXHAUST HOLE SIZE
• 6° ENGINE GIMBAL	• EXHAUST HOLE SIZE
• ENGINE LAYOUT	• EXHAUST HOLE SIZE • HOLDDOWN CONCEPT AND LAYOUT
• AFT UMBILICAL I/FS	• RISE-OFF TYPE UMBILICALS

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Figure 1.2-3. LRB MLP Flight Element Specifications

FLIGHT ELEMENT SPECIFICATION	STATION SET CONFIGURATION*
• LENGTH	• GOX VENT ARM
• DIAMETER	• ET H2 VENT ARM
• AFT SKIRT DIAMETER	• ET H2 VENT ARM
• ENGINE LAYOUT	• FLAME DEFLECTOR
• 6° ENGINE GIMBAL	• FLAME DEFLECTOR
• PROPELLANT TYPE	• STORAGE/HANDLING/ XFER • FLAME DEFLECTOR

*STATION SET CONFIGURATION AS A FUNCTION DERIVED FROM THE FLIGHT ELEMENT SPECIFICATION

Figure 1.2-4. PAD Flight Element Specifications.

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The LRB ground processing requirements were derived from an analysis of the LRB processing flow. Figures 1.3-1, 1.3-2 and 1.3-3 document this processing flow and display a network logic diagram for the LRB processing facility, LRB MLP/VAB, and LRB MLP/Pad respectively.

Figures 1.3-4 through 1.3-7 integrate the LRB processing flow diagrams and present a generic ground processing timeline. These timelines in a multi-flow ground processing environment influence the station set solutions in terms such as quantity and capacity.

1.4 INTERFACE REQUIREMENTS

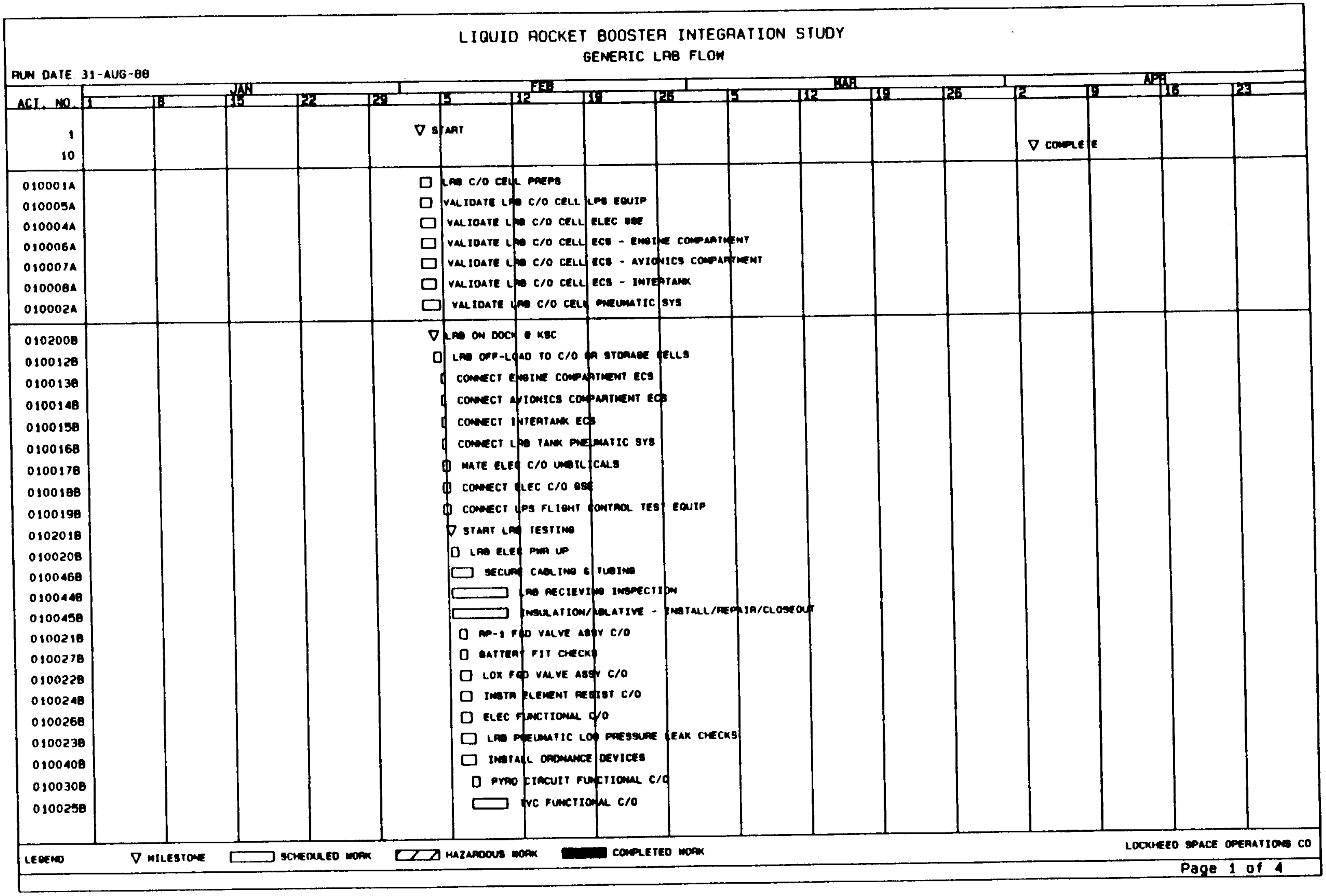
The station set design solutions must comply with a multitude of other interface requirements. These requirements can be categorized as either functional or physical, and are dependent on the selected methods of design, development and acquisition.

The following is a generic list of typical standards that must be accommodated by the design and during the subsequent implementation:

- Military (MIL)
- Space Transportation System (STS)
- Kennedy Space Center (KSC)
- Department Of Transportation (DOT)
- Occupational Safety & Health Administration (OSHA)
- Environmental Protection Agency (EPA)
- Applicable Building Codes
- Industry Standards

1.5 ACTIVATION MANAGEMENT

Integration of a new generation of flight hardware at the launch site, concurrent with an on-going man-rated STS program is an understated management challenge. During the 1990's timeframe, when LRBs are introduced at KSC it is envisioned that the current KSC work force will be totally dedicated to processing and launching SRB/STS flight hardware, at a flight rate of 14 missions a year.



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Figure 1.3-4. LRB Ground Processing Requirements Generic LRB Flow (Page 1 of 4).

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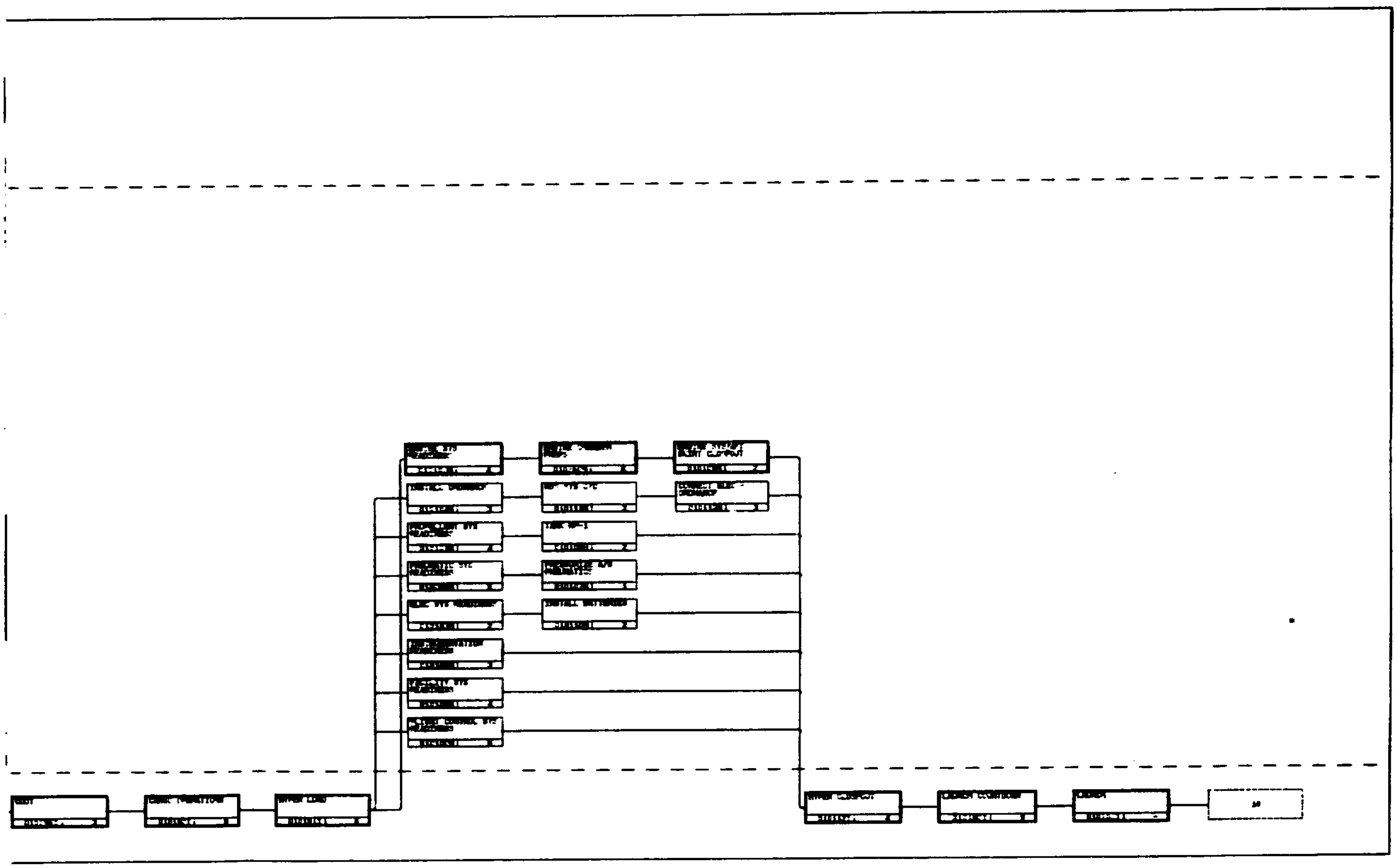
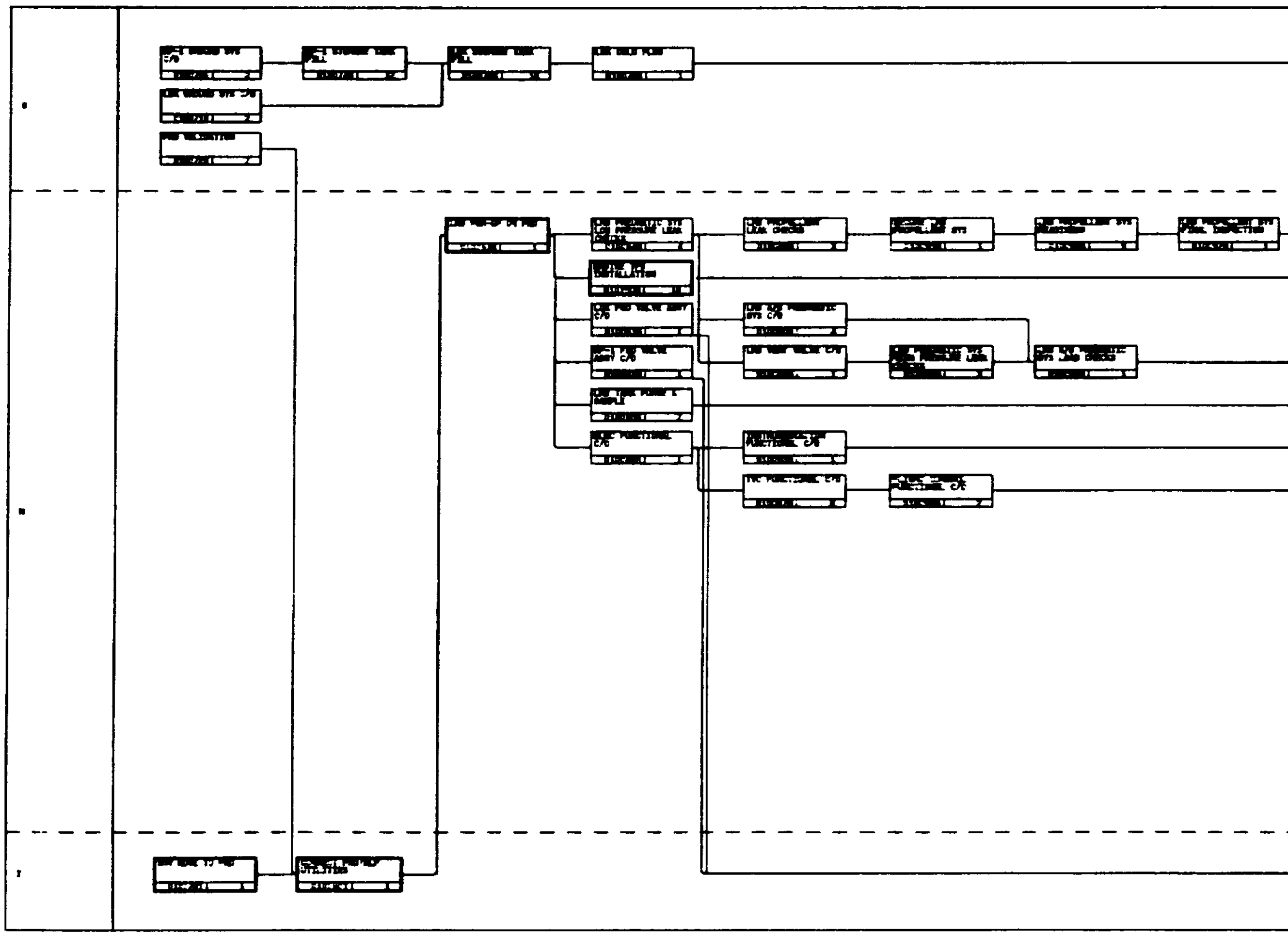
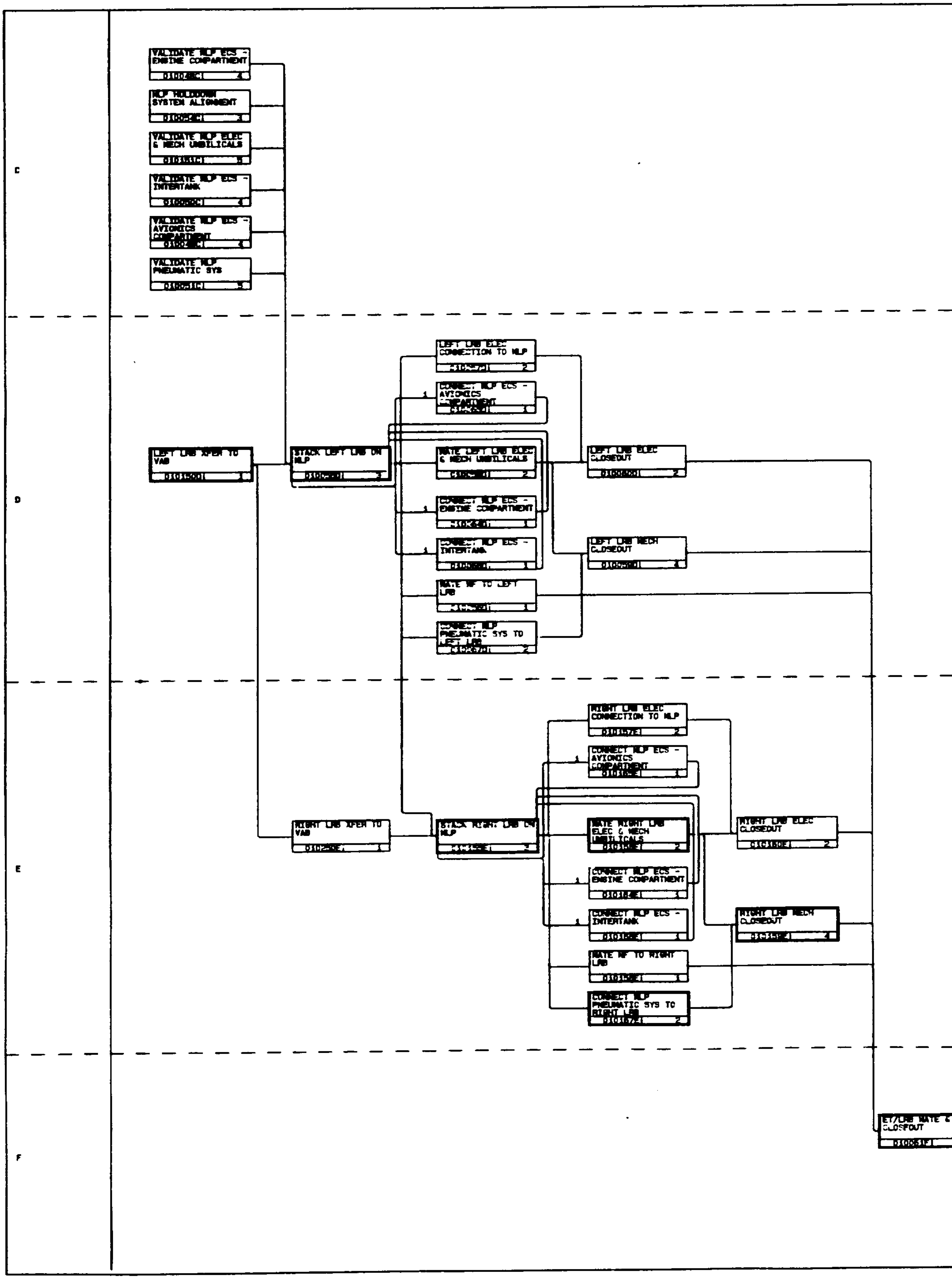


Figure 1.3-3. LRB MLP/Pad Processing Flow Diagram.



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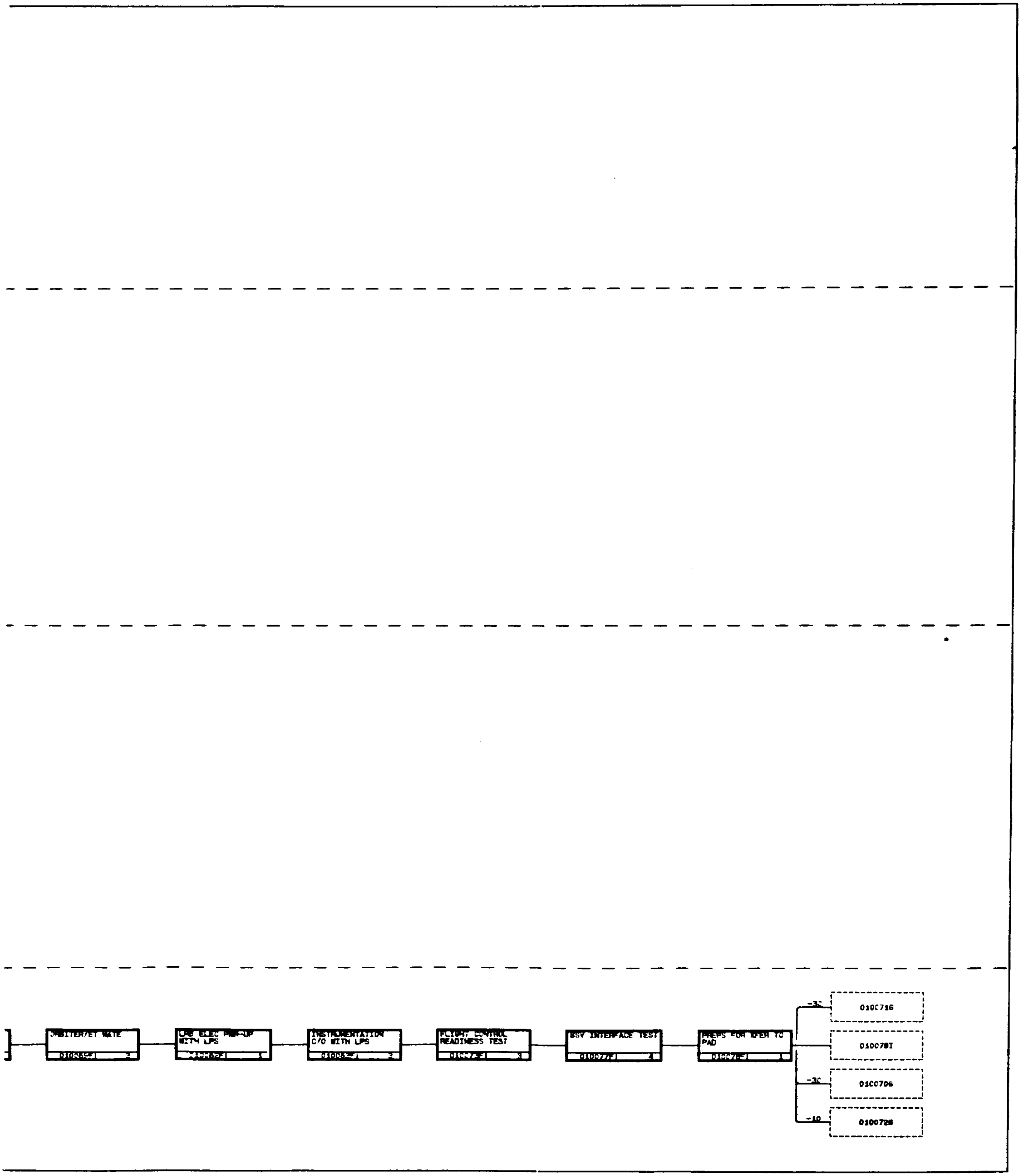
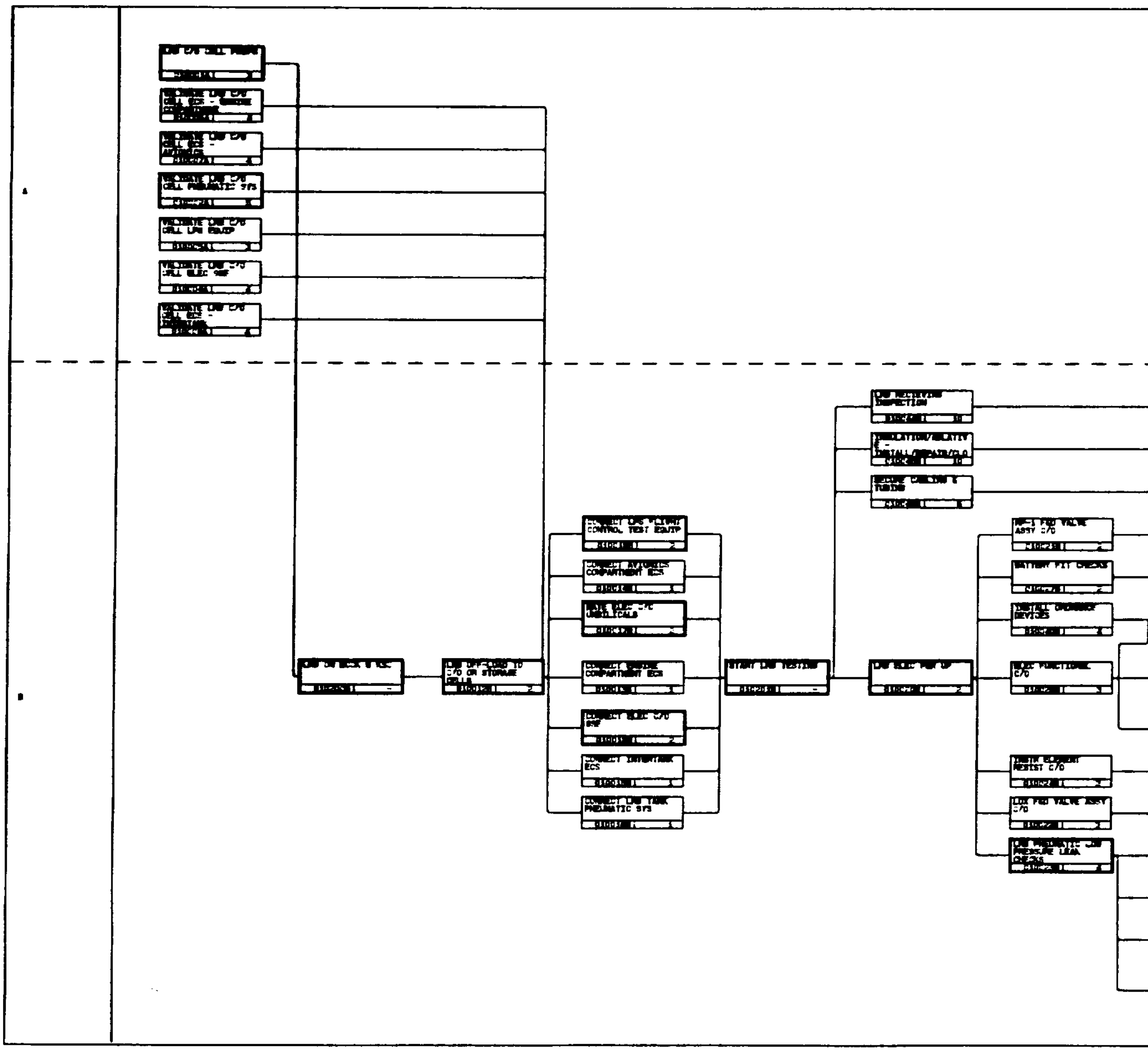


Figure 1.3-2. LRB MLP/VAB Processing Flow Diagram.

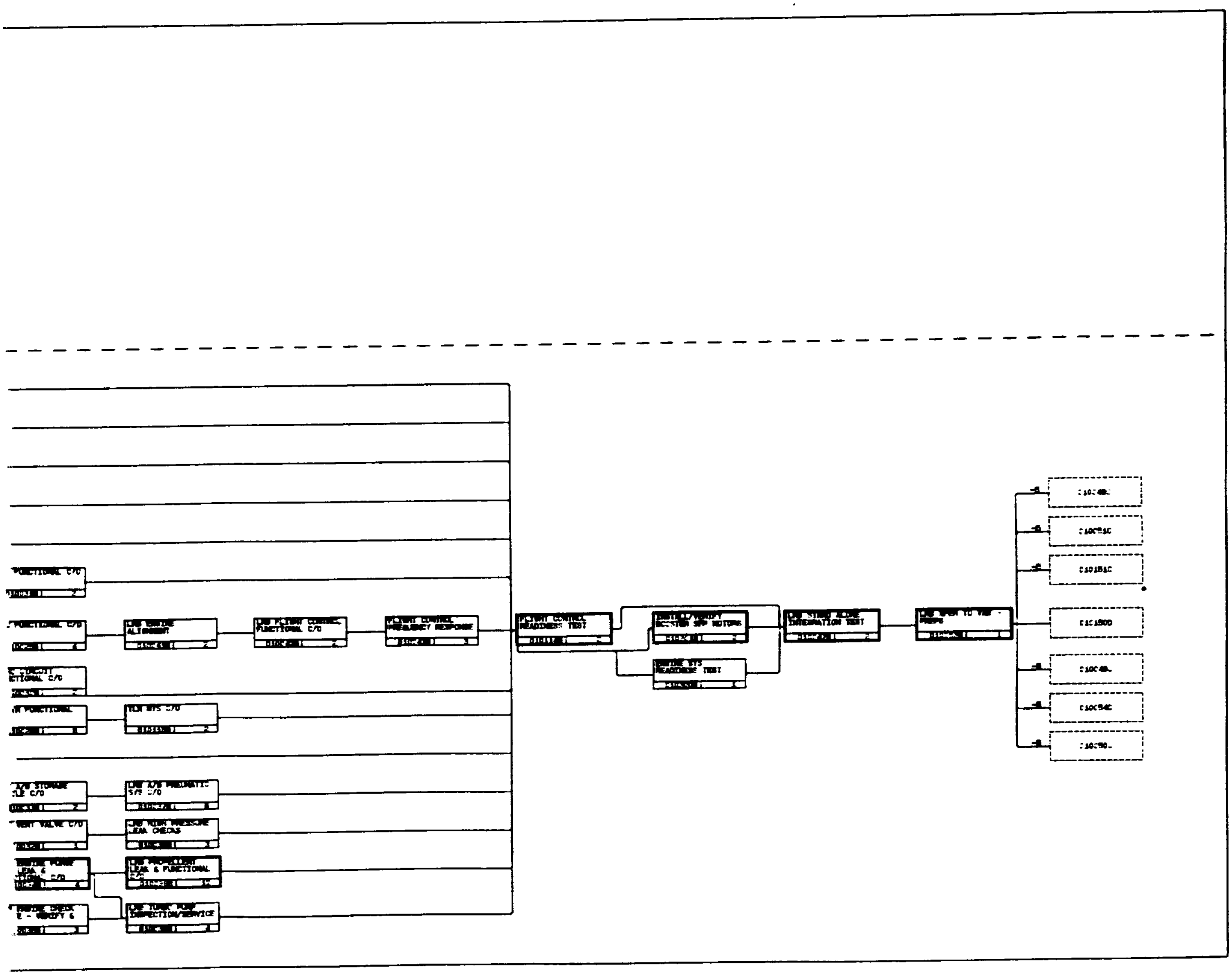
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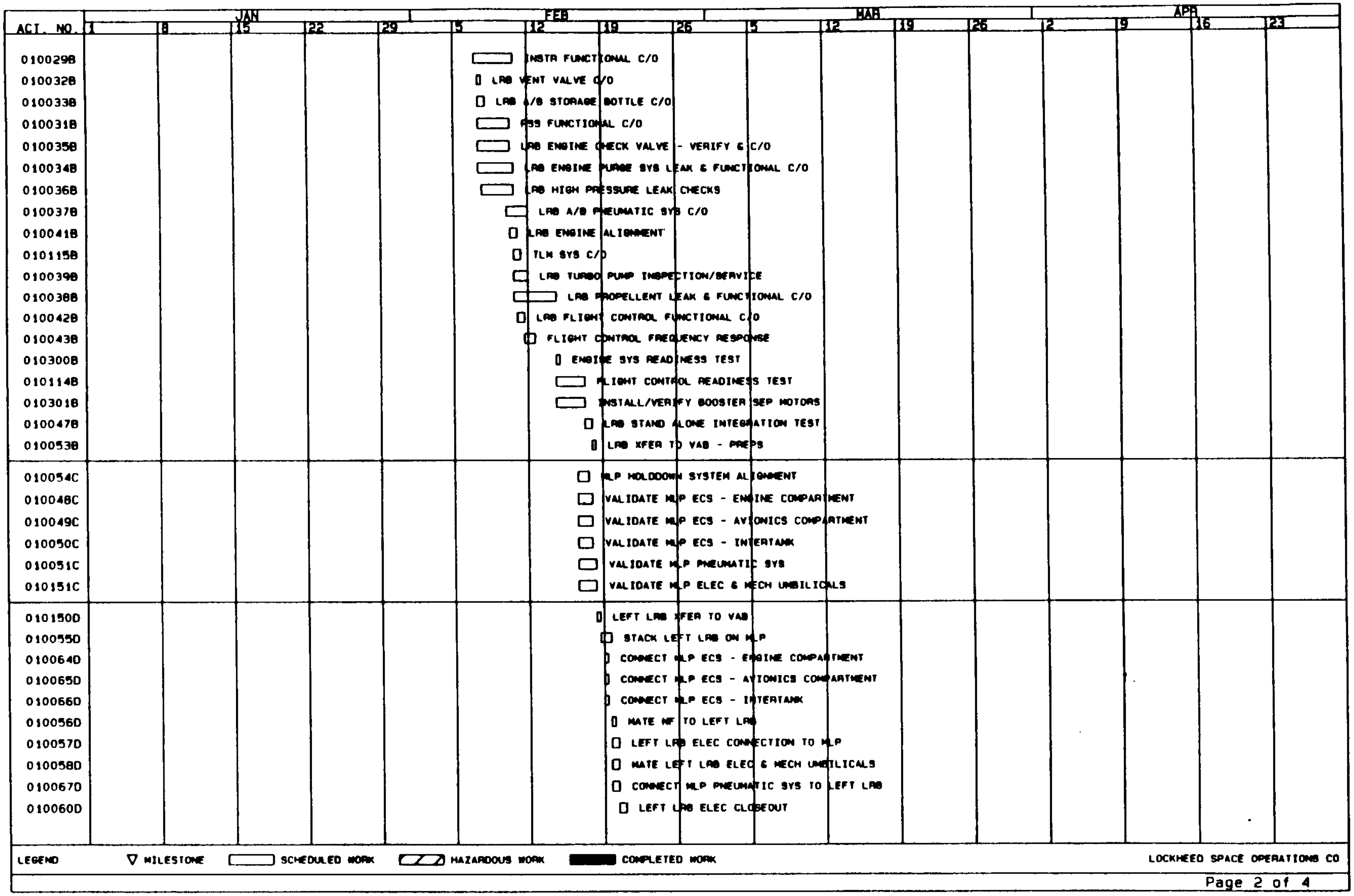
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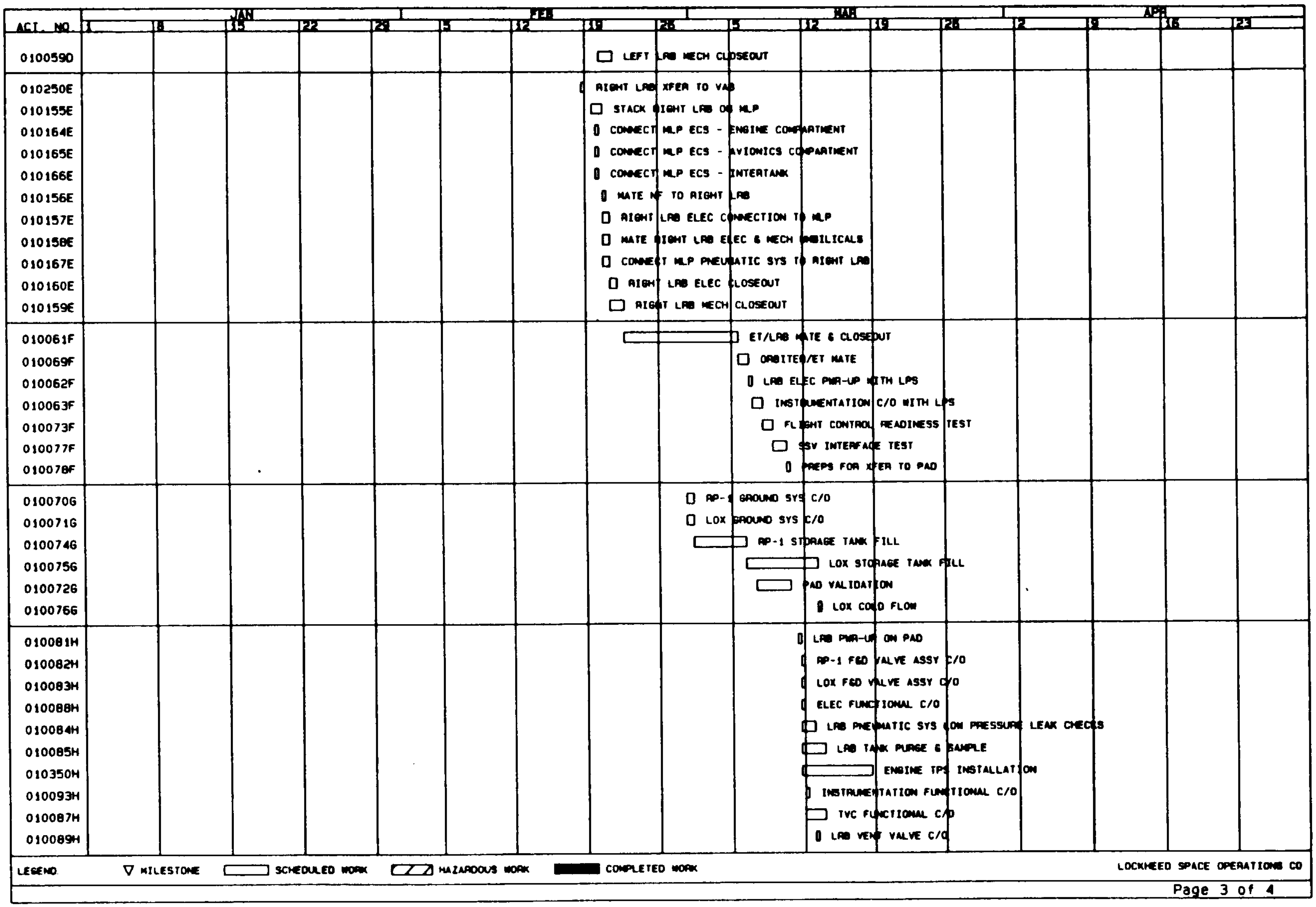
Figure 1.3-1. LRB Processing Facility Flow Diagram.



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Figure 1.3-5. LRB Ground Processing Requirements Generic LRB Flow (Page 2 of 4)

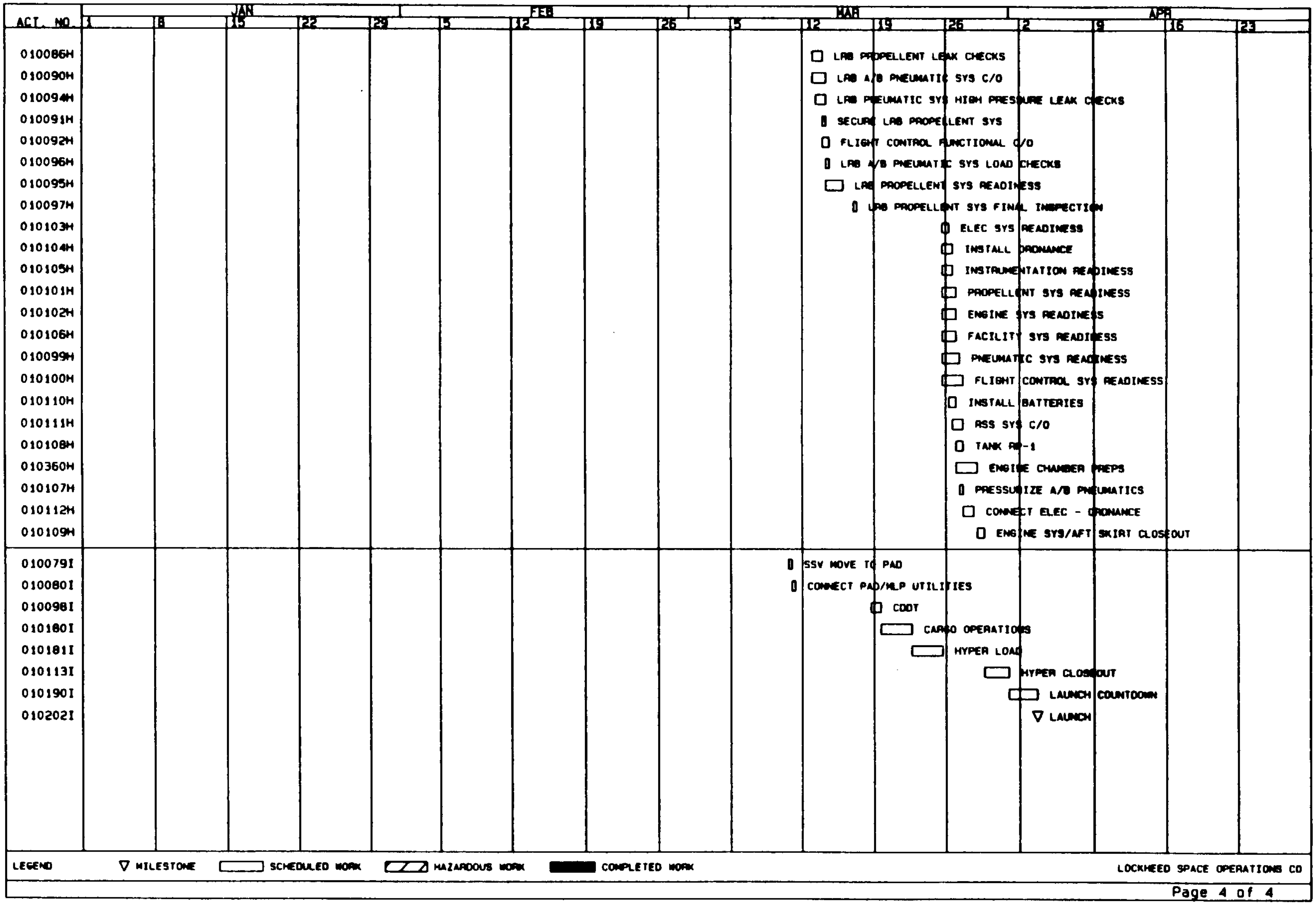
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Figure 1.3-6. LRB Ground Processing Requirements Generic LRB Flow (Page 3 of 4)

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Figure 1.3-7. LRB Ground Processing Requirements Generic LRB Flow (Page 4 of 4)

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One of the primary groundrules established in this Phase-A study is to minimize the impacts to the SRB/STS program. This groundrule is applicable not only to the hands-on processing team but extends to the KSC management cadre, and major functions such as sustaining engineering, logistics, support operations and LPS.

To assure an orderly and efficient integration of LRBs into the STS program, a centralized organization will be created to manage the KSC activation effort, and function as a support organization to the NASA LRB program lead. The LRB Activation Management Team will exist external to the formal SRB/STS organization structure.

The LRB Activation Management Team has the primary responsibility to provide for funding, design, procurement, implementation and verification and a secondary responsibility during the certification process. It will afford the administrative functions of control, direction, coordination and evaluation at both the program and project levels.

During the LRB Activation program's design phase, this team will procure and administer the A&E contracts, coordinate the sustaining engineering interfaces and assure the design integrity and compatibility through the design review process. Specifications will be developed for implementation by construction, procurement and fabrication contracts. Configuration will be maintained with an automated configuration management and change control system and supported by a dedicated field engineering group.

During the implementation phase, the LRB Activation Management Team will procure and administer the facility construction contracts and the procurement/fabrication contracts for LSE,GSE and initial spares. Quality control and integrated logistics functions will be provided. Site access will be coordinated and overall schedule, status and project control capability will be developed and maintained.

During the verification phase, the activation team will procure and administer the TTV type contracts. All technical reviews, configuration inspections, system tests and O&M integration will be coordinated. Procedures will be developed for verification testing and interim O&M. Property transfer documents and system data packages will be prepared for turnover to the operator.

Figure 1.5 presents the activation management requirements relative to the primary functions of each.

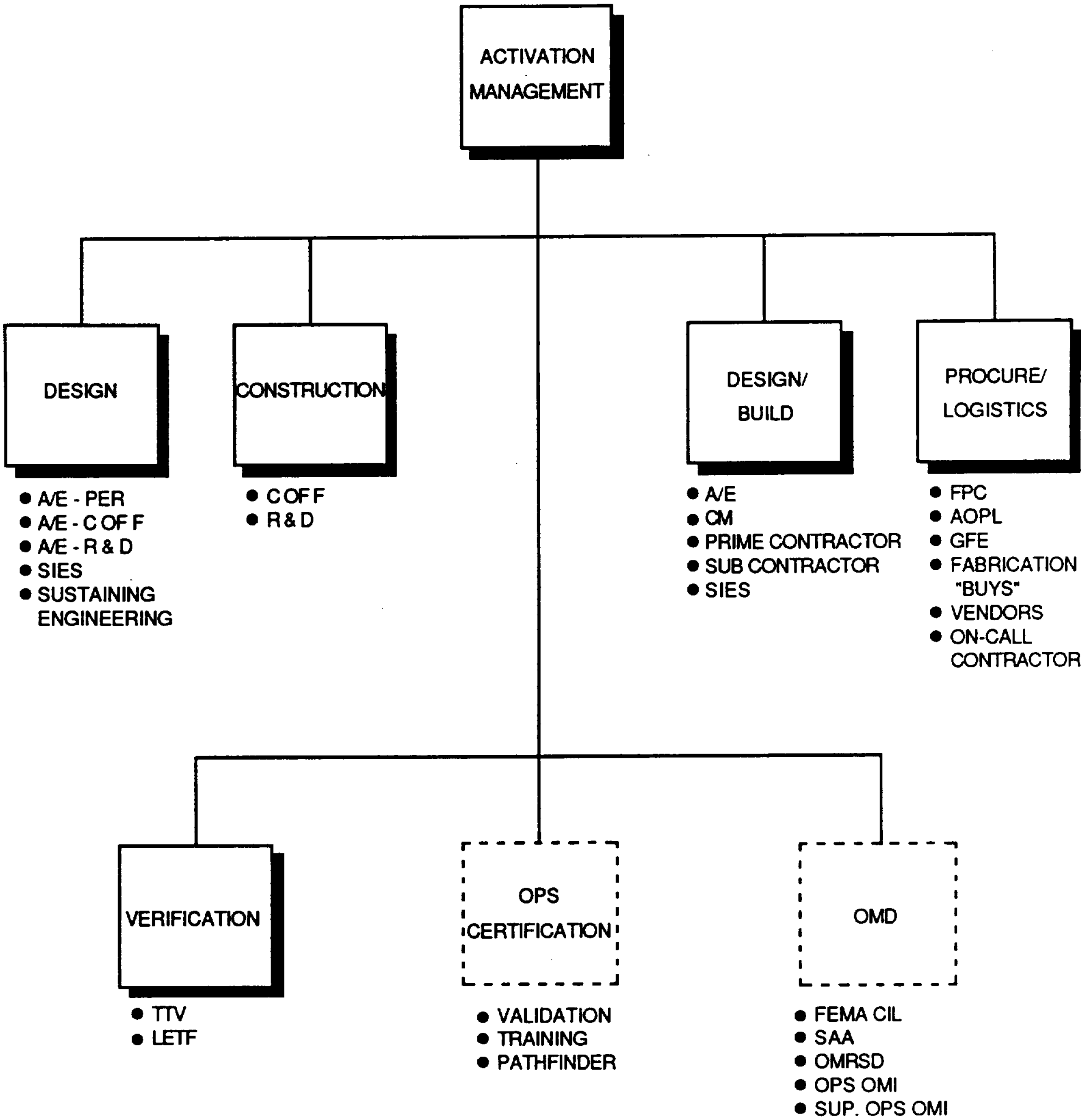


Figure 1.5. LRB Activation Management.

The LRB Activation Management Team will be organized as a combined NASA and contractor community. In centralizing the activation functions and capabilities, some cultural changes may be required at KSC.

The initial activation manpower requirements are approximately 140 to 145 personnel, and peaks at approximately 360 to 365 personnel in support of the first line facility activation. The second line facility activation manpower requirements are significantly reduced and vary from approximately 50 to 135 personnel. Volume III Section 6 documents the LRB manpower and discusses the activation management team in further detail.

1.6 ET/LRB HORIZONTAL PROCESSING FACILITY (HPF)

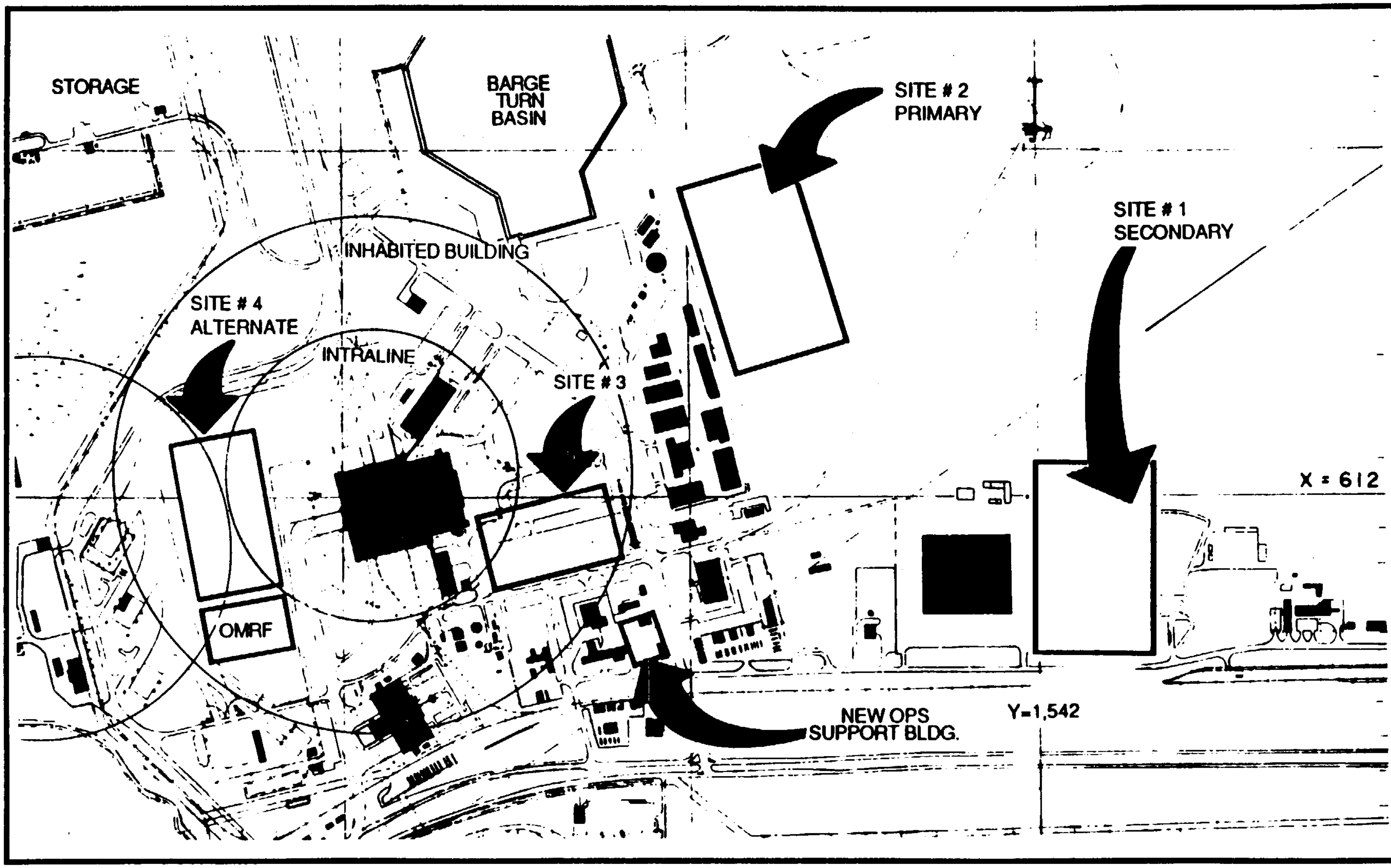
This section of the Ground Operations Plan addresses the horizontal ground processing of External Tanks (ET) and Liquid Rocket Boosters. Both processing functions will be housed geographically in one standalone facility with a proposed location adjacent to the existing LC - 39 press site. Figure 1.6-1 is the siting plan, and reflects the primary and alternate sites under consideration.

Subject facility will provide a functional processing and checkout area for the External Tanks currently processed vertically in the VAB High Bays 2 and 4. This, in turn, makes VAB HB-4 available for modification to support LRB/STS integration. The ET Processing Facility station set will be constructed as Phase-1 of a multi-phase implementation. This station set will be similar in configuration to the ET Checkout Facility (station set V-33) at the Vandenburg Launch Site (VLS). Figure 1.6-2 reflects an isometric of the VLS station set V-33.

The second phase of the processing facility will house the Liquid Rocket Booster areas which will comprise of booster surge/storage area, booster processing area, engine shop, logistics area, electrical/avionics shop, machine shop, TPS shop, battery lab, and administrative offices. Figure 1.6-3 displays a conceptual facility layout.

Facility implementation schedule milestones by phase are as follows:

- Phase-1 ET Processing Facility
  - ATP: October 1990 (EARLY)
    January 1991 (LATE)

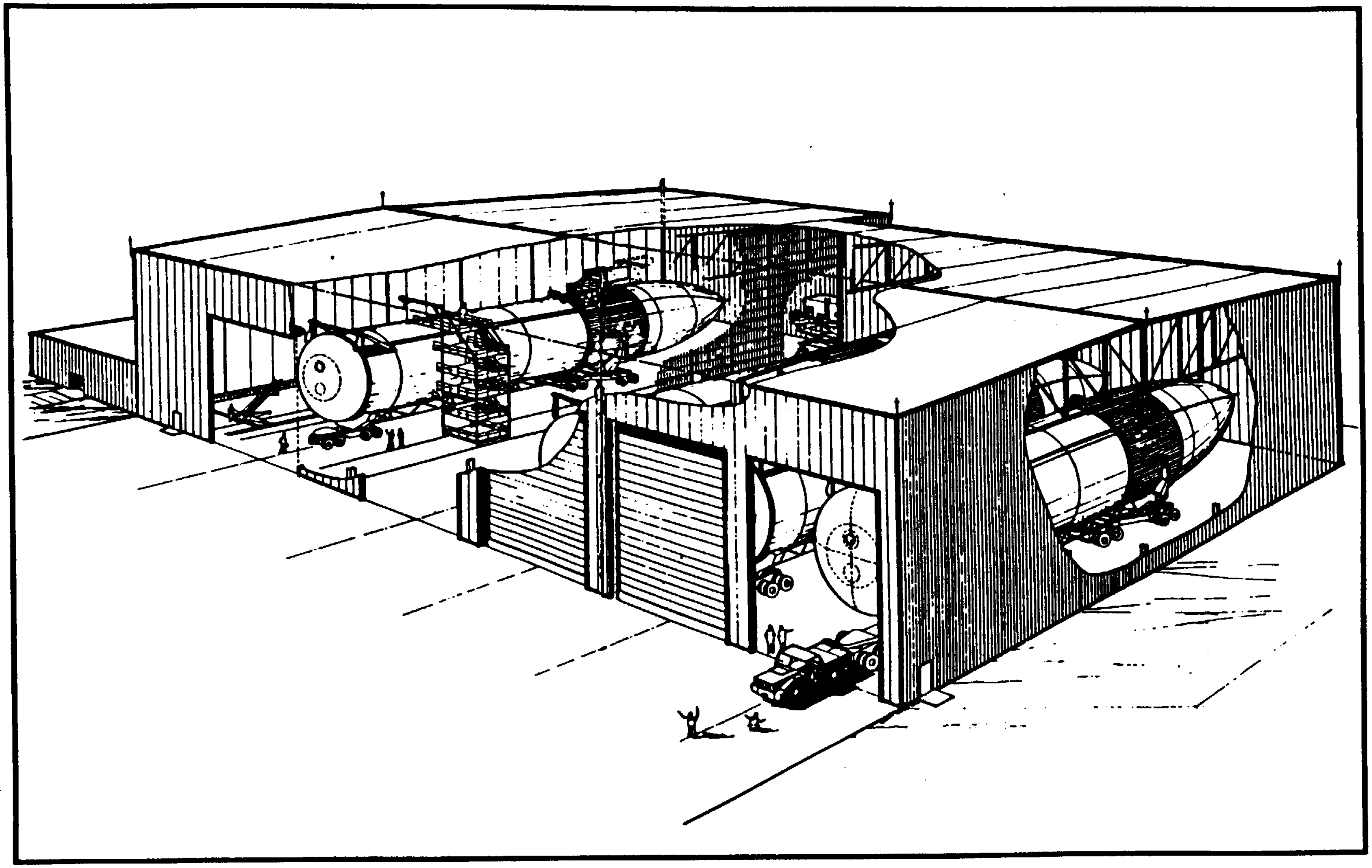


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Figure 1.6-1. ET/LRB Horizontal Processing Facility - Site Plan

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Figure 1.6-2. ET Processing Facility - V33 Station Set

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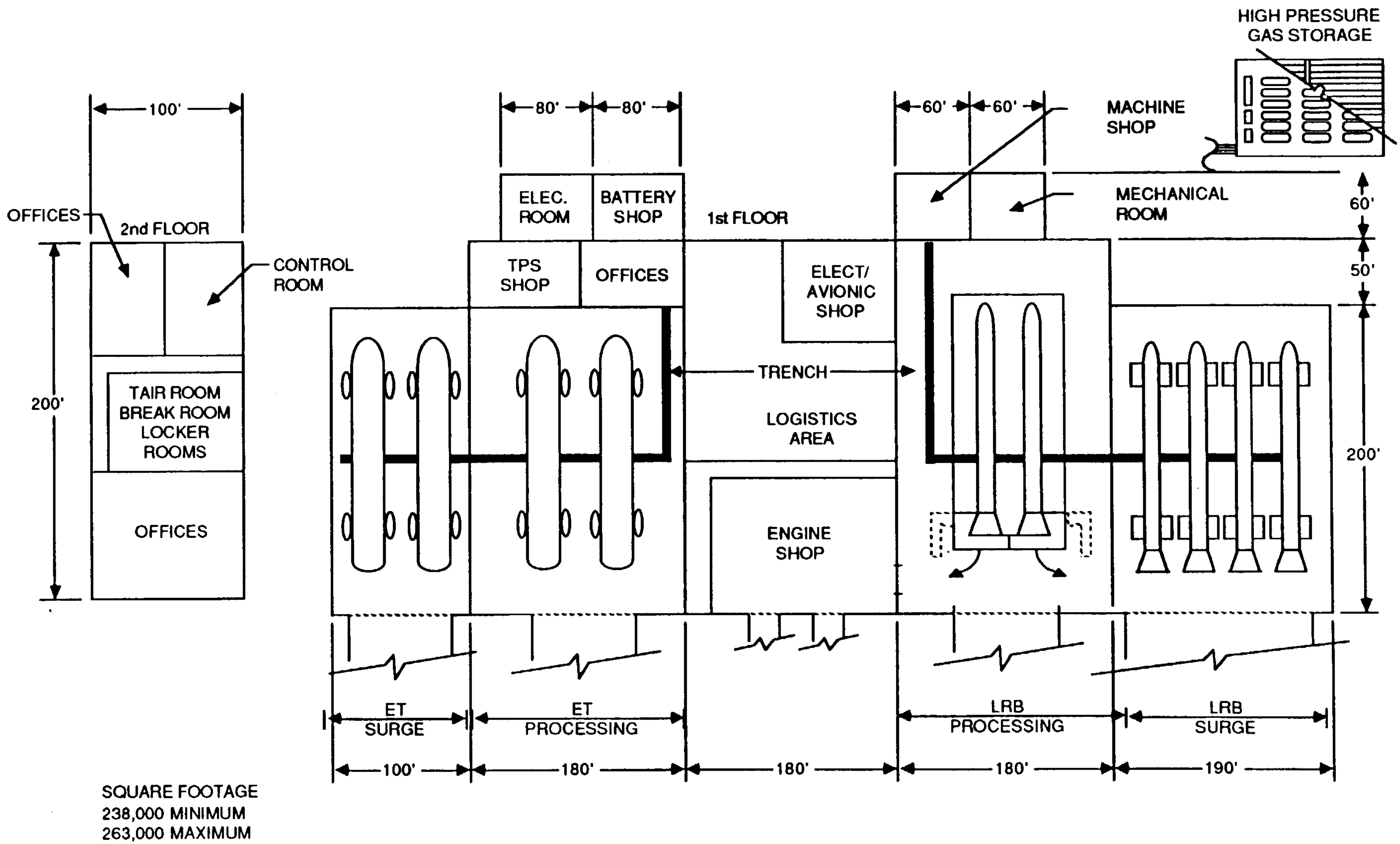


Figure 1.6-3. ET/LRB Horizontal Processing Facility Layout Plan.

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- ORD: March 1993

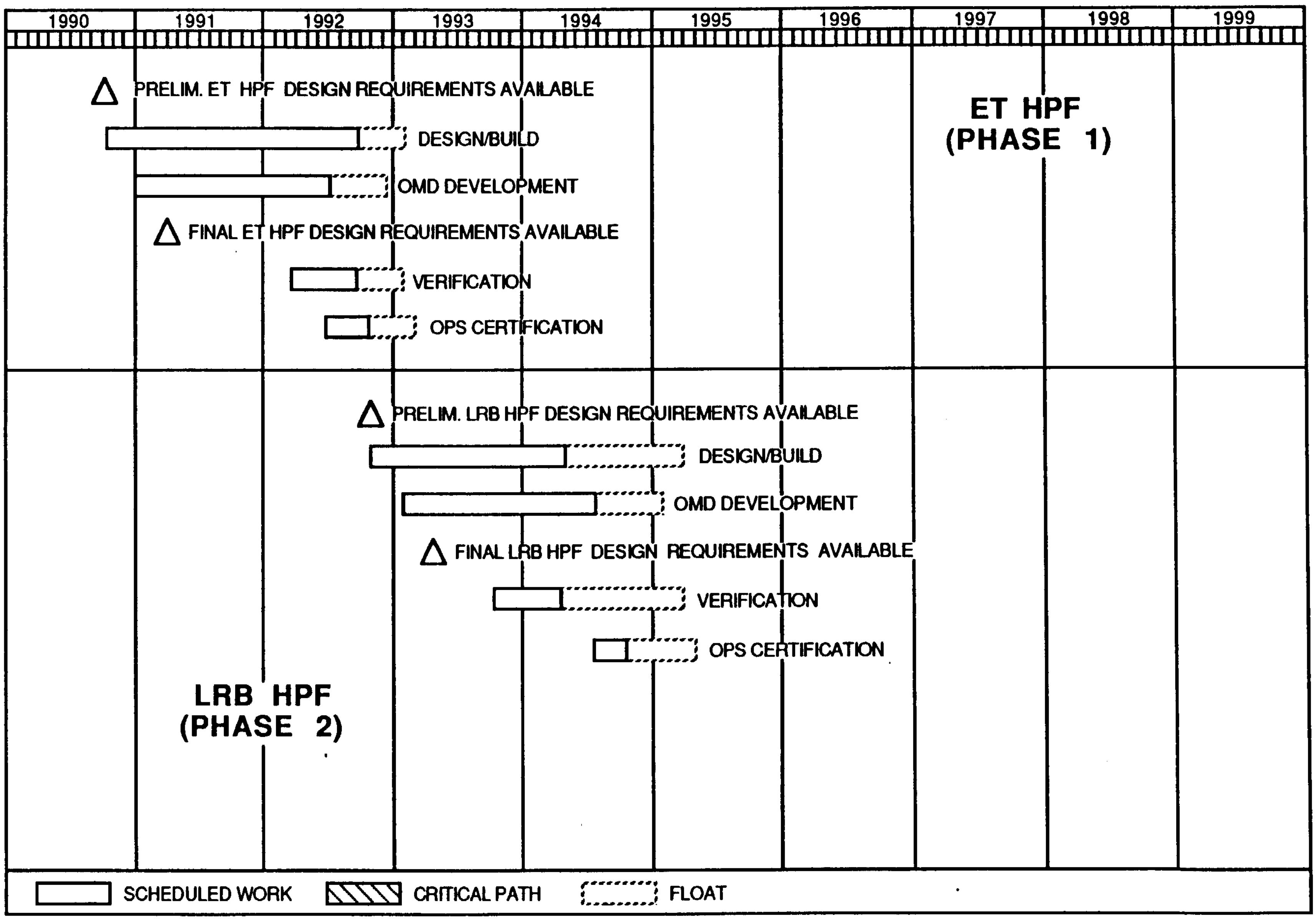
- Phase-2 LRB Processing Facility

  - ATP: October 1992 (EARLY)
    April 1993 (LATE)
  - ORD: April 1995

End-to-end implementation requires 26 months for Phase-1 and 24 months for Phase-2, and has 4 and 6 months schedule flexibility per phase, respectively. Adherence to this schedule will provide continuity of ET processing with minimal STS program impacts. It will also afford assimilation of LRBs into the STS program in parallel with SRB usage with no program impacts. Figure 1.6-4 is the conceptual implementation plan for both phases.

With the current government trend of realigning funding authority and contracting policies, this Phase-A study proposes to take advantage of more cost and schedule effective approaches to project planning. The opportunity exists to proceed with a design/build implementation which will in essence, provide KSC with a turnkey operation. Under the LRB design/build implementation concept, the A & E services, construction management team and prime construction contractor are procured from one source. Sub-contractor procurement, coordination and integration is the responsibility of this contractor. Ground support equipment is designed, and procured under a typical sub-contractor relationship. Long lead items are identified and early design and procurement are implemented.

In theory, the design/build technique is both cost and schedule efficient. It is most adaptable to a new facility versus a modified existing facility. KSC has had recent positive experience with this method of implementation. To insure further success, a number of key design/build elements must be emphasized. Design must be closely and timely coordinated with the users and operators. The facility and GSE requirements, upon definition, are "set in concrete". The construction manager must be experienced and intimate with their design team. The design/build contractor's logistics organization must insure timely delivery of materials, equipment and personnel, while assuring fair and adequate procurement competition.



81006-01G

Figure 1.6-4. ET/LRB Horizontal Processing Facility Implementation Plan

3-1.6 12/1 8:00am

The scope of work for Phase-1 and Phase-2 are basically identical, with some exceptions. These exceptions are as follows:

- Phase-1 ET Processing Facility
  - Site preparation and utility services for both the ET and LRB processing facility station sets
  - The common tow way
  - The superstructure for the "Low Bay" area and the outlying structures
  - Outfitting of the TPS Shop, Mini LPS Control Room, Logistics Area, and some administrative areas
- Phase-2 LRB Processing Facility
  - Outfitting of the engine shop, electrical/avionics shop, battery lab, machine shop, and remaining administrative areas

The total ROM cost impact associated with the ET/LRB HPF station sets is $84.3 million for the LO2/RP-1 pump-fed and LO2/RP-1 pressure-fed (MMC) configurations; and $90.2 million for the LO2/LH2 pump-fed and LO2/RP-1 pressure-fed (GDCC) configurations. The price difference is primarily due to the increase in facility size, to support the longer LRB configurations. Costs are excluded for the additional ET and LRB horizontal ground transporters required to support the current ground processing scenario.

1.6.1 LRB Engine Shop

To support engine related processing activities, a dedicated area of the ET/LRB Horizontal Processing facility, no less than 18,000 square feet, will be located adjacent to the LRB processing area, designated "engine shop". This station set will provide the centralized capability of performing all major engine related work in the processing facility and support remote engine work in the VAB, on the MLP, and at the launch pad.

The engine shop will provide for receipt, inspection, storage, LRU installation & removal, verification and check-out of LRB engines. Contingency maintenance of the engines and any related operations allied to the GSE required for engine processing, will be instituted also. Figure 1.6.1 presents a conceptual engine shop layout. LRB engine operations will fall under three categories: engine handling, checkout and servicing and facility support. The GSE required to support these activities is still in the conceptual stage, however, as a guideline at this time, it is anticipated that this GSE will not differ radically from existing SSME ground support equipment. Volume III section 18 of this report details the engine shop GSE requirements.

Two procurement options are under consideration for the engine shop GSE. The first option is to include this work in the scope of the design/build contract. The second option is to have the LRB engine manufacturer coordinate the design, fabrication, certification testing and delivery to KSC.

The total ROM cost impact associated with this station set is $33.4 million, and does not differ significantly for any LRB configuration. These costs are limited to the engine shop GSE and the initial spares. Facility costs are included in the ET/LRB HPF station set.

1.7 VAB HIGH BAY 4

This section of the Ground Operations Plan addresses the requirement for a separate LRB/STS integration facility in the Vehicle Assembly Building - designated High Bay 4.

Modification activity in High Bay 4 will start following completion of Phase-1 of the ET/LRB Horizontal Processing facility. The ET and SRB vertical processing structures and GSE presently located in HB-4 will be disassembled and removed. New orbiter, ET and LRB access platforms will be custom designed and built to suit the LRB/STS configuration. Access for the LRBs will include the aft-skirt, intertank and nose areas. Combined Orbiter/ET access will include the 2nd and main floor of Platform "D", roof and 2nd floor of platform "B" and main floor of Platform "E". If the longest LRB configurations are selected, High Bay 4 will require additional platforms similar to Platform "C" in High Bays 1 & 3. Figure 1.7-1 depicts the design concept for flight hardware access in VAB HB-4, utilizing an extensible platform system.

GSE similar to that existing in High Bays 1 & 3 will be required in HB-4 for integration testing of the Orbiter/ET. In addition, an ECS system will be required to purge the LRBs. This will consist

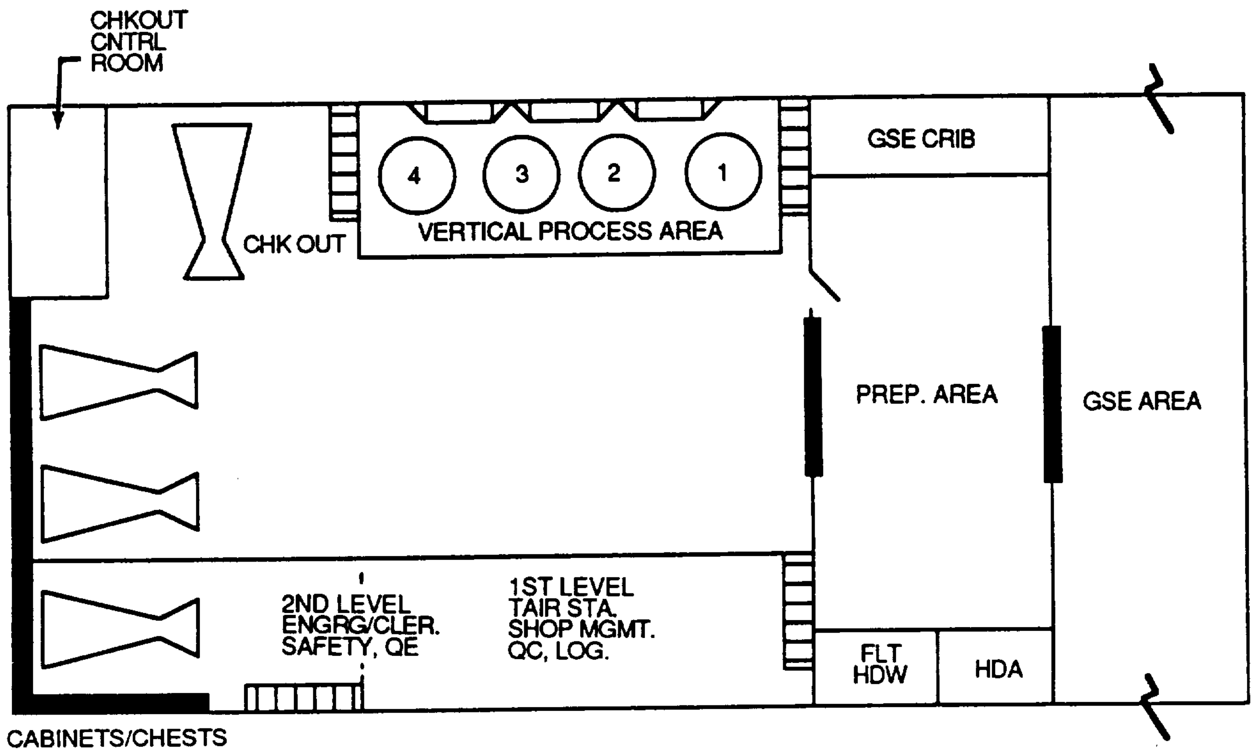
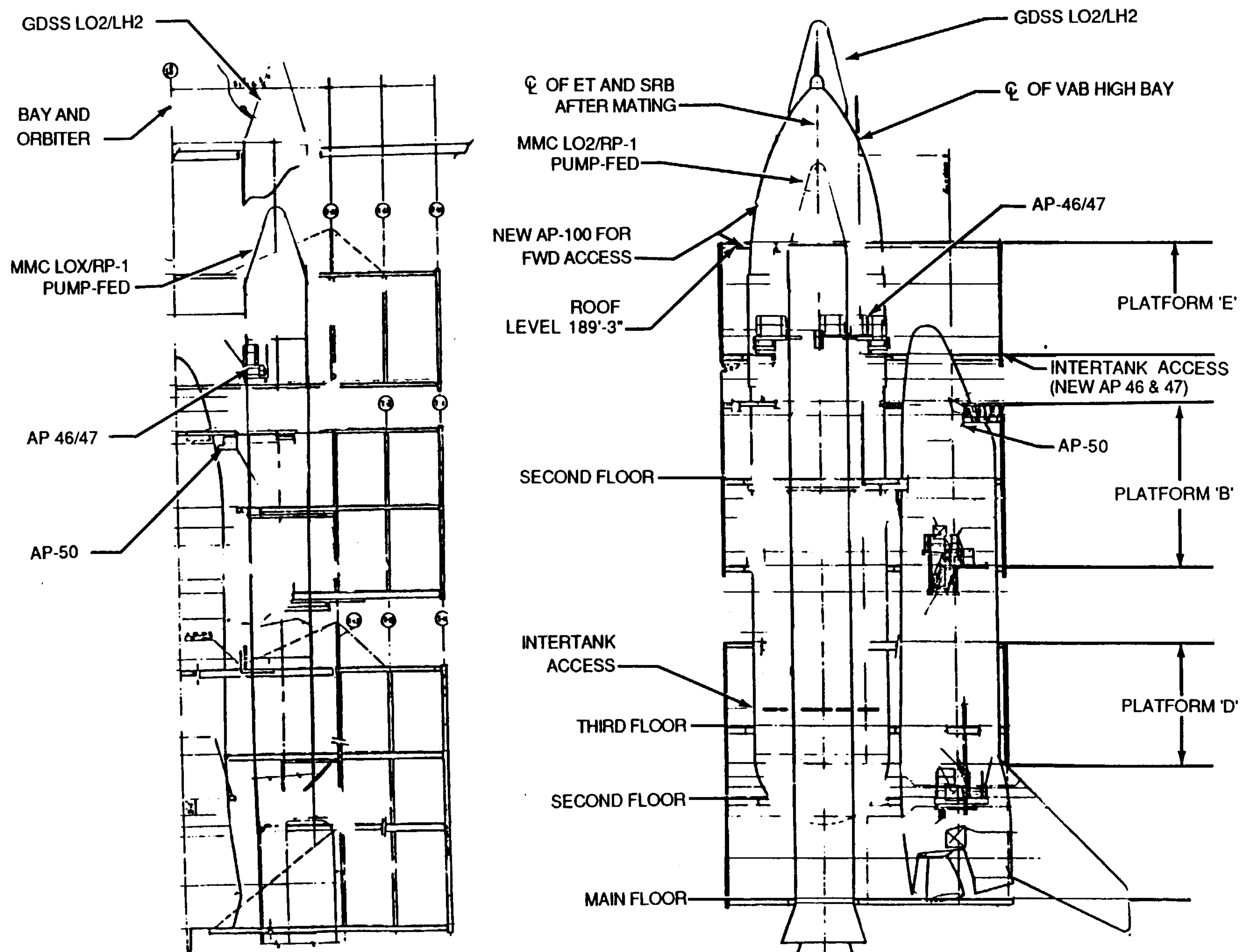


Figure 1.6.1. LRB Engine Shop Conceptual Layout

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3-1.6 11/3 noon



Vehicle Access Platforms and Vehicle Key Elevations

81005-01BE

Figure 1.7-1. VAB High Bay 4 Elevation.

3-1 12/1 8:00a

of six stations, each equipped with blowers, cooling coils, heaters and filter assemblies. Each ECS station will be dedicated to the aft-skirt, mid-body and nose cone areas, three per LRB.

Facility implementation schedule milestones are as follows:

- ATP: October, 1990 (EARLY)
  September, 1992 (LATE)
- ORD: June, 1995

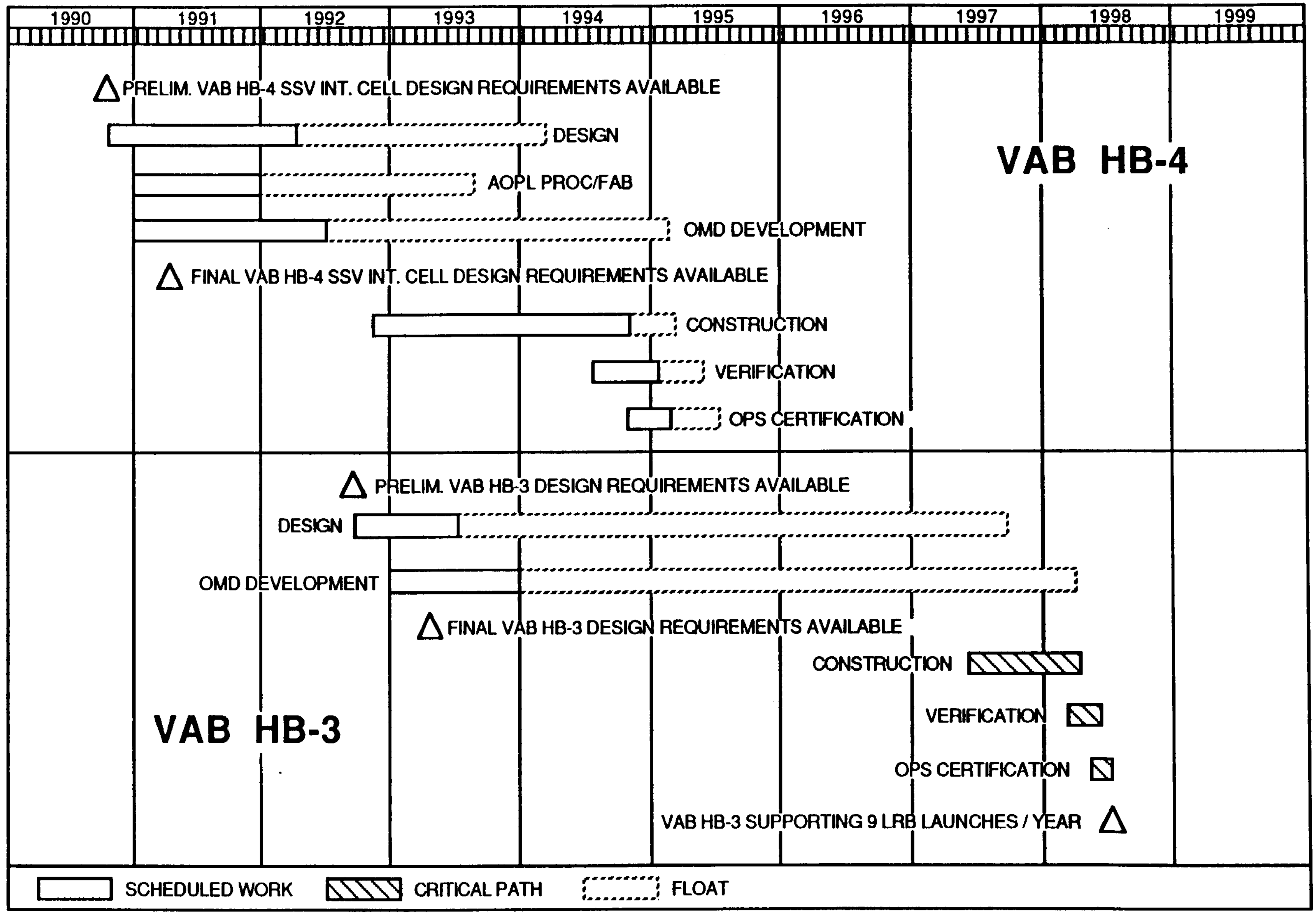
Design requires 18 months and can proceed upon the availability of the preliminary design requirements. Construction requires 24 months, affording approximately five months of schedule flexibility or float, for the on-site activity. Figure 1.7-2 displays the current conceptual implementation plan for the VAB HB-4 and VAB HB-3.

It is intended to award a single fixed price construction contract with A&E participation. It is anticipated that the entire project will have to be undertaken on off-shifts with the ongoing SRB/STS hazardous operations in the VAB, to preclude any schedule conflict. To control debris and contamination generated from the construction activity, a suitable barricade system should be installed at the transfer aisle side of HB-4 to a level whereupon the overhead crane would still be able to access. Staging for all work will be limited to the ground level of HB-4 and immediately adjacent on the crawlerway.

This study has not addressed the extensive asbestos problem associated with this station set. High Bay 4 structural modifications may require penetration and/or removal of existing asbestos wall panels. Asbestos abatement requirements will significantly impact both cost and schedule.

The total ROM cost impact relative to this station set is $29.8 million for the LO2/RP-1 pump-fed and LO2/RP-1 pressure-fed (MMC) configurations; and $33.4 million for the LO2/LH2 pump-fed and LO2/RP-1 pressure-fed (GDCC) configurations. The cost delta is primarily due to the difference in LRB length, requiring additional access platforms and superstructure.

Following verification and certification, VAB HB-4 will support the proposed LRB pathfinder activities and the first 15 to 17 LRB/STS missions.



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Figure 1.7-2. VAB Implementation Plan

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1.7.1 VAB High Bay 3

The present High Bay 3 platform configuration is designed to support the SRB/STS flight configuration only. With the advent of LRBs into the program and as the LRB flight rate ramps up to nine missions per year, it will be necessary to provide an additional LRB/STS integration facility. High Bay 3 will be converted to support the LRB/STS configuration with the SRB/STS processing capability maintained.

The larger diameter of all the LRB configurations will necessitate extensive modification to the platform system. If the longer LRB configurations are employed, further modifications to the upper ET access platforms would be required. Prior to SSV roll to the launch pad, the extensible platforms are retracted and the flip-ups platforms are raised to provide exit clearance. The flip-up sections have to be modified to provide the prescribed 18" clearance required for vehicle ingress and egress from the VAB. Figure 1.7.1 displays a typical extensible platform modification.

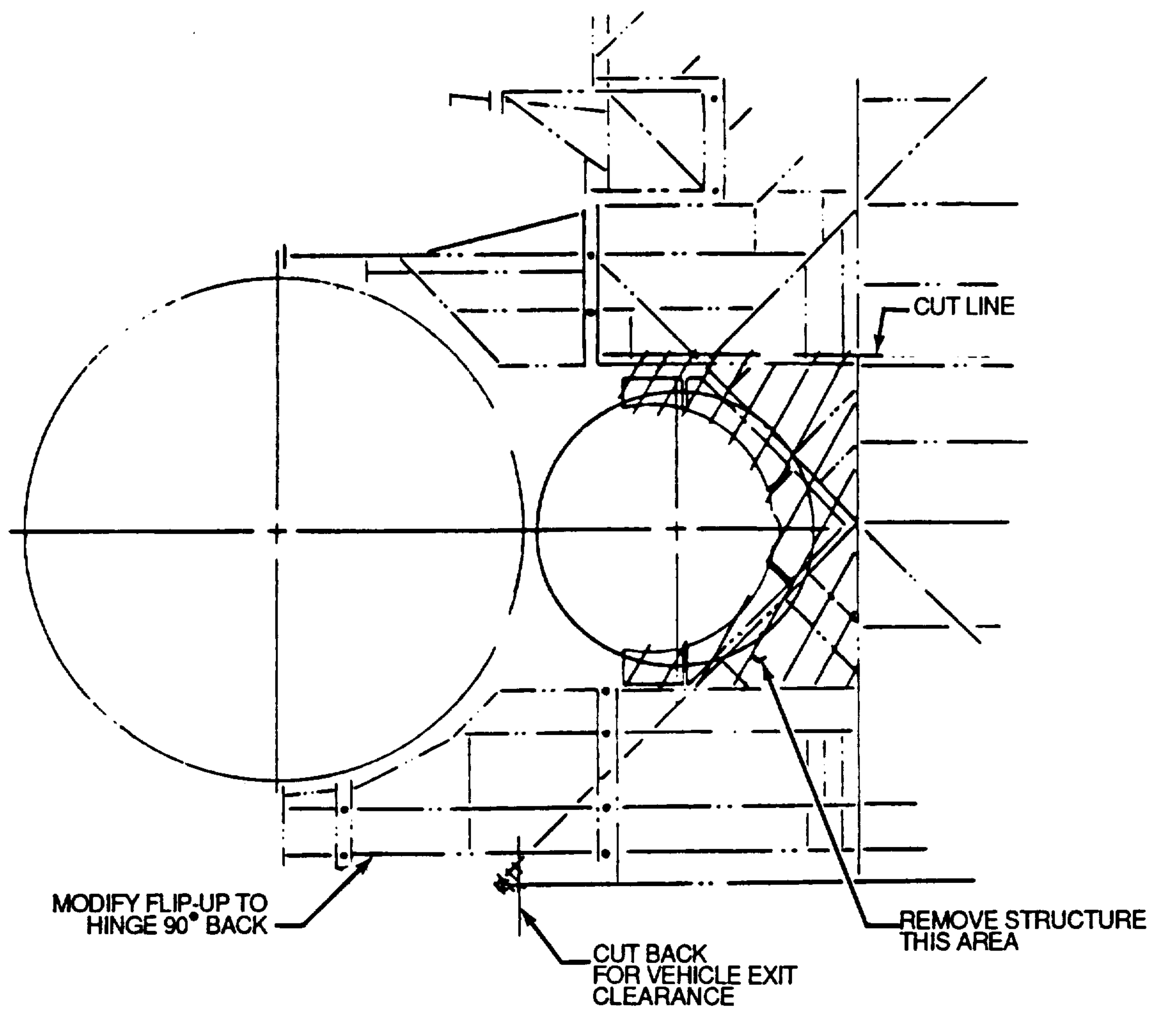
All extensible platform modifications will be accomplished with the platforms in place in lieu of removal to an off-site location. This will allow for parallel structural, mechanical and electrical activity. It will provide a significant cost savings and a schedule savings of approximately 6 months by eliminating platform removal, transportation to and from an off-site area, reinstallation, realignment and testing. The technical risk of potential racking of the extensible platform superstructure is also eliminated.

Facility implementation schedule milestones are as follows:

- ATP: October, 1992 (EARLY)
  December, 1996 (LATE)
- ORD: July, 1998

Design requires approximately nine (9) months and will be accomplished by an A&E contractor. It is intended to award a single fixed price contract for construction. This activity requires approximately ten (10) months duration, and is schedule critical upon commencement of on-site work.

To minimize program schedule risk all HB-3 activity will proceed on an "around - the - clock" basis. The initial two months of construction will be limited to mobilization, field measurements,



TYPICAL MODIFICATION
(ROOF OF PLATFORM 'D' SHOWN)

Figure 1.7.1 VAB High Bay 3 Typical Platform Modification (Plan).

procurement and off-site fabrication on a non-interference basis with STS operations, thus maintaining SRB/STS processing capability for as long as possible.

All HB-3 modification work must be coordinated with the on-going SRB/STS and LRB/STS processing activities in HB-1 and HB-4 respectively. This is a daily interface requirement, for such things as welding and system outages, and the imposition of "real time" planning inefficiencies is expected. Unfortunately, this is the nature of doing business in the VAB.

The total ROM cost impact for this station set is $11.7 million. Cost does not differ significantly for any LRB configuration.

1.7.2 VAB High Bay 4 Crawlerway

In order to utilize VAB High Bay 4 as an LRB/STS integration facility, reactivation of the High Bay crawlerway is required. The crawlerway will start at the High Bay doors, and extend approximately 1400 linear feet to the existing crawlerway, at a point northwest of the Orbiter Maintenance and Refurbishment Facility (OMRF).

Prior to commencing with the actual crawlerway construction activity, a number of smaller tasks must be accomplished. The OPF modular housing will be relocated, and the OPF east parking lot will be demolished. Parallel power, communication and mechanical services will be installed prior to removal or abandonment in place of existing services that currently route through, below or on-top of the proposed crawlerway. Figure 1.7.2 presents a site layout of the High Bay crawlerway and identifies the facility and system impacts.

Design will require approximately 6 months and implementation will require approximately 14 months. This effort can commence as early as October 1990 and has 33 months of schedule flexibility or float. Construction must be complete no later than December 1994 to support the VAB High Bay 4 certification activity and subsequent LRB pathfinder program.

Design will be accomplished by an A&E contractor, and implementation by a single fixed price contract. The total ROM cost associated with the VAB HB-4 crawlerway scope of work is $5.9 million.

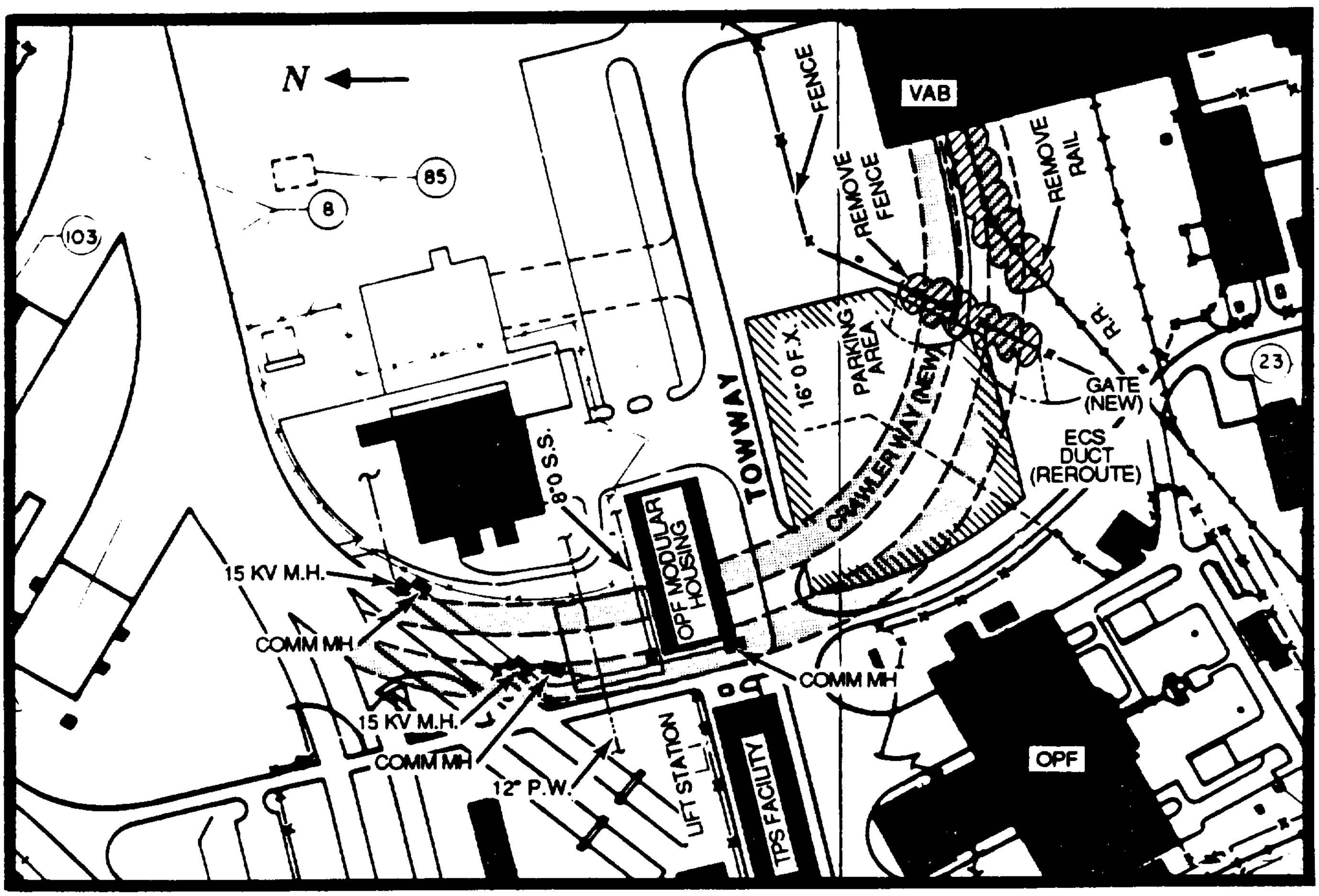


Figure 1.7.2. VAB HB-4 Crawlerway Site Plan.

1.8 LRB MOBILE LAUNCH PLATFORM (MLP)

This Phase-A study has maintained the current STS scenario of Space Shuttle Vehicle (SSV) integration in the Vehicle Assembly Building (VAB), for the KSC launch site. This dictates continuing with the program requirement for Mobile Launch Platforms (MLP).

To support a flight rate of fourteen (14) LRB/STS missions per year, a total of two LRB configured MLPs will be required. Analysis of the multi - flow ground processing model indicated that each LRB MLP will accommodate a minimum of seven (7) LRB flights per year, with some schedule contingency available.

Both LRB MLPs will be designed and built new. This conclusion is based upon program schedule criteria more than technical issues. Conversion of an existing MLP to LRB configuration is a five (5) year project. Regardless of ramp rate options and MLP conversion schedule opportunities, an impact to SRB/STS flight rate would occur.

The LRB MLP configuration will be customized to suit the LRB/STS flight vehicle only. MLPs will not be interchangeable between the liquid boosted and solid boosted STS. The design solution will be restricted to some extent. The current ET and Orbiter positions on the integrated stack must be maintained. The MLP external dimensions and existing ground system interface locations must be preserved. Existing ET, Orbiter and payload systems GSE and LSE must be accommodated.

Prominent LRB MLP design features include enlarged booster exhaust holes, holddown mechanisms with soft release systems, additional propellant tunnels, RP-1 service umbilicals, ground power and instrumentation umbilicals, and cryogenic T-O lift-off type umbilicals. Figure 1.8 presents an isometric of a Mobile Launch Platform in its current configuration.

1.8.1 Mobile Launch Platform (MLP) #4

A total of 59 months is required for end-to-end implementation of MLP #4, and is the current critical path for LRB activation at KSC. Authority to proceed (ATP) is required by October 1990 and the Operational Readiness Date (ORD) is scheduled for August 1995. This supports the proposed LRB pathfinder program and LRB Initial Launch Capability (ILC). Figure 1.8.1 displays the current conceptual implementation plan for MLP #4 and #5.

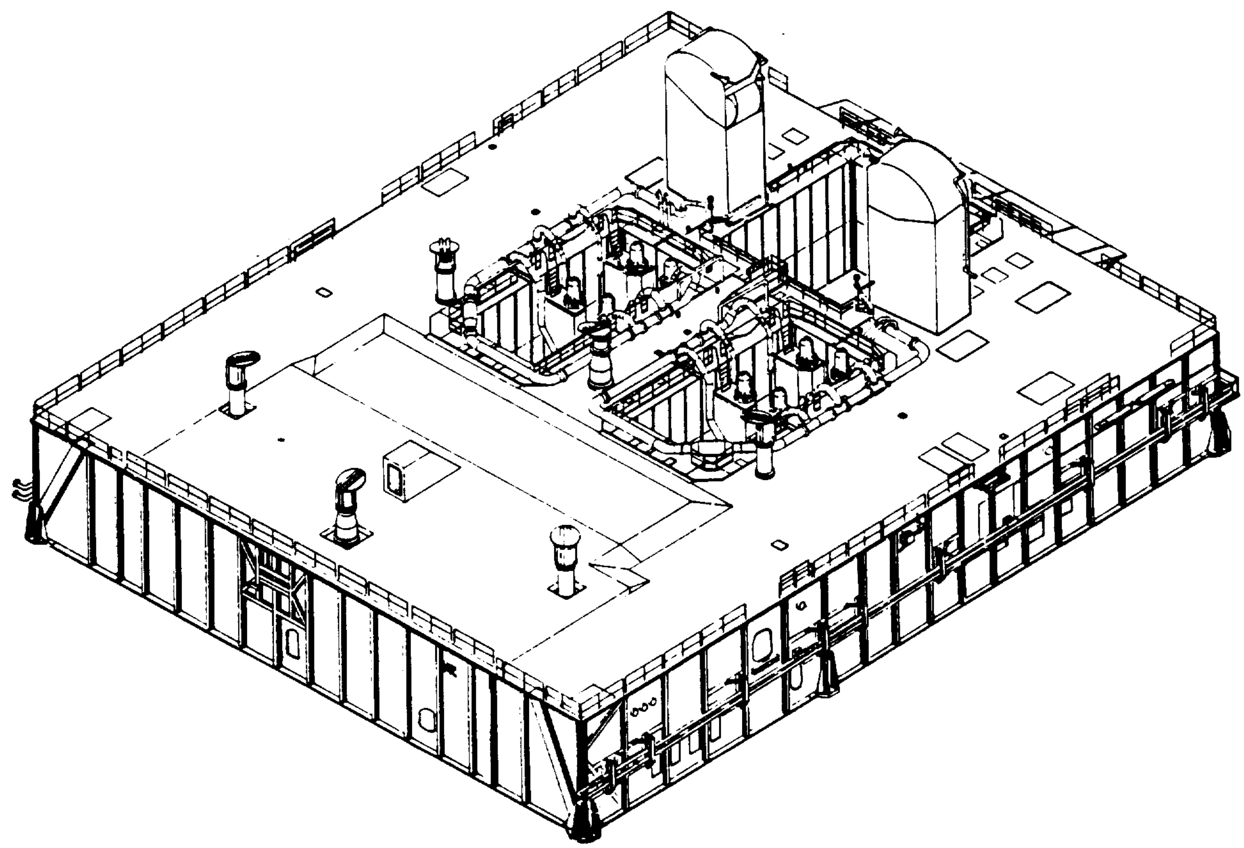
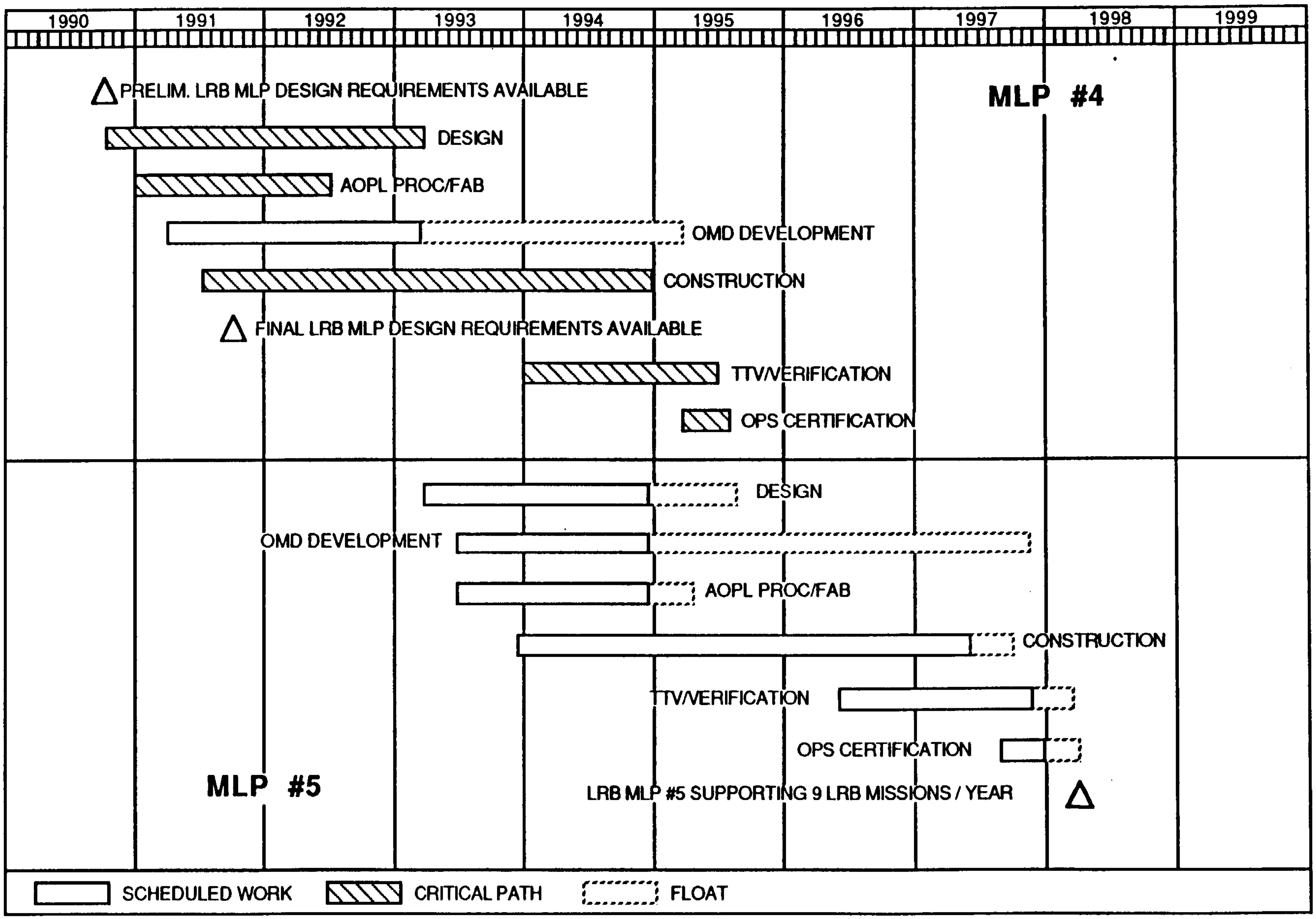


Figure 1.8. MLP Current Configuration.



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Figure 1.8.1. LRB MLP Implementation Plan

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Design will be procured through one prime A/E contract, approximately thirty (30) months in duration. A&E participation will continue through ORD with extended Title I and II services, including Site Inspection and Engineering Services (SIES). Due to the specialized engineering disciplines required for the MLP design, it is anticipated that the prime A/E contractor will subcontract extensively throughout the A&E community.

Construction will proceed in two phases, allowing for a planned incorporation of LRB programmatic changes while minimizing cost and schedule impacts. Both phases will be implemented by fixed price contract.

Phase-1 will be approximately twenty-four (24) to twenty-seven (27) months in length, with six (6) to nine (9) months joint occupancy planned with the Phase-2 construction contract. Phase-1's scope of work includes fabrication and erection of the MLP superstructure and supporting falsework, installation of the sound suppression and quench water systems, procurement and installation of the facility electrical and mechanical systems, and completion of all architectural type work.

Phase-2 is planned for twenty-four (24) months in duration, with nine (9) to twelve (12) months joint occupancy with the following verification contract. A number of incremental completion requirements will be imposed, permitting a logical system by system turnover. Phase-2's scope of work includes fabrication and installation of the overpressure and deluge piping, engine service platforms, and holddown mechanism haunches, installation of the Orbiter Tail Service Masts (TSM), and placement of the ground systems piping and cabling.

Verification will be implemented utilizing a prime Termination/Test/Verification (TTV) type contractor. This is projected for eighteen (18) months duration, with three (3) months beneficial occupancy with the following certification phase. The scope of work includes preparation of all system test procedures, installation of all GSE end items, installation of the LSE hold down mechanisms and propellant umbilicals, and the termination,test and verification of all of the above.

Operational certification will be performed by the Shuttle Processing Contractor (SPC). This is the final phase in the hands-on activation effort. It is important to note that the SPC is an active participant in the design development, and verification testing. Prior to the start of actual certification testing by system, the SPC will prepare the Operations & Maintenance Instruction (OMIs),

perform SAA and FEMA/CIL analysis, and staff and train systems engineers and operating personnel. Certification testing is expected to require four (4) months.

To support the multi - phase implementation schedule, a number of early procurements and fabrications have been identified. These include the structural girders, vacuum-jacketed cryogenic piping and hardware, cable assemblies, GSE end items and all LSE.

It is important to note, that the 59 month implementation schedule could be compressed by approximately 9 to 12 months, if the LRB program requirements dictate. Schedule acceleration can be accommodated in the construction and verification phases, as a trade-off to a budget impact of approximately 15% to 20%. Also, there is a technical risk of proceeding too fast. LRB programmatic changes are expected, and cannot be efficiently incorporated into the ground system design solution, in an accelerated project schedule environment.

The total ROM cost impact relative to this station set is $176.2 million for all the LO2/RP-1 configurations and $191.5 million for the LO2/LH2 pump-fed configuration. The cost difference is primarily due to the addition of two LH2 T-O lift-off umbilicals, LH2 cryogenic pipe, and control instrumentation.

1.8.2 Mobile Launch Platform (MLP) #5

The second LRB MLP will be basically identical in configuration to the first LRB MLP. This second line facility is required to support a LRB flight rate of eight (8) or more missions per year, currently projected to occur in fiscal year 1998.

End-to-end implementation will again require fifty-nine (59) months, with the milestones as follows:

- ATP: April 1993 (early)
October 1993 (late)
- ORD: April 1998

This schedule affords three (3) months of flexibility or float, and is based upon the start of MLP #5 design restrained by the completion of MLP #4 design.

Design will require approximately 21 months to accomplish, and is effectively a "wash-off" of the mature MLP #4 engineering. All level I and II program changes and level III and IV project level changes will be incorporated.

The construction, advanced procurement, verification and certification phases of implementation will be typical to MLP #4 conceptual planning. The only notable difference is to utilize Orbiter, ET and payload GSE from an existing SRB configured MLP. This provides a significant cost savings and can be accommodated in the program schedule as early as mid-1996, when SRB/STS flight rates are ramping down.

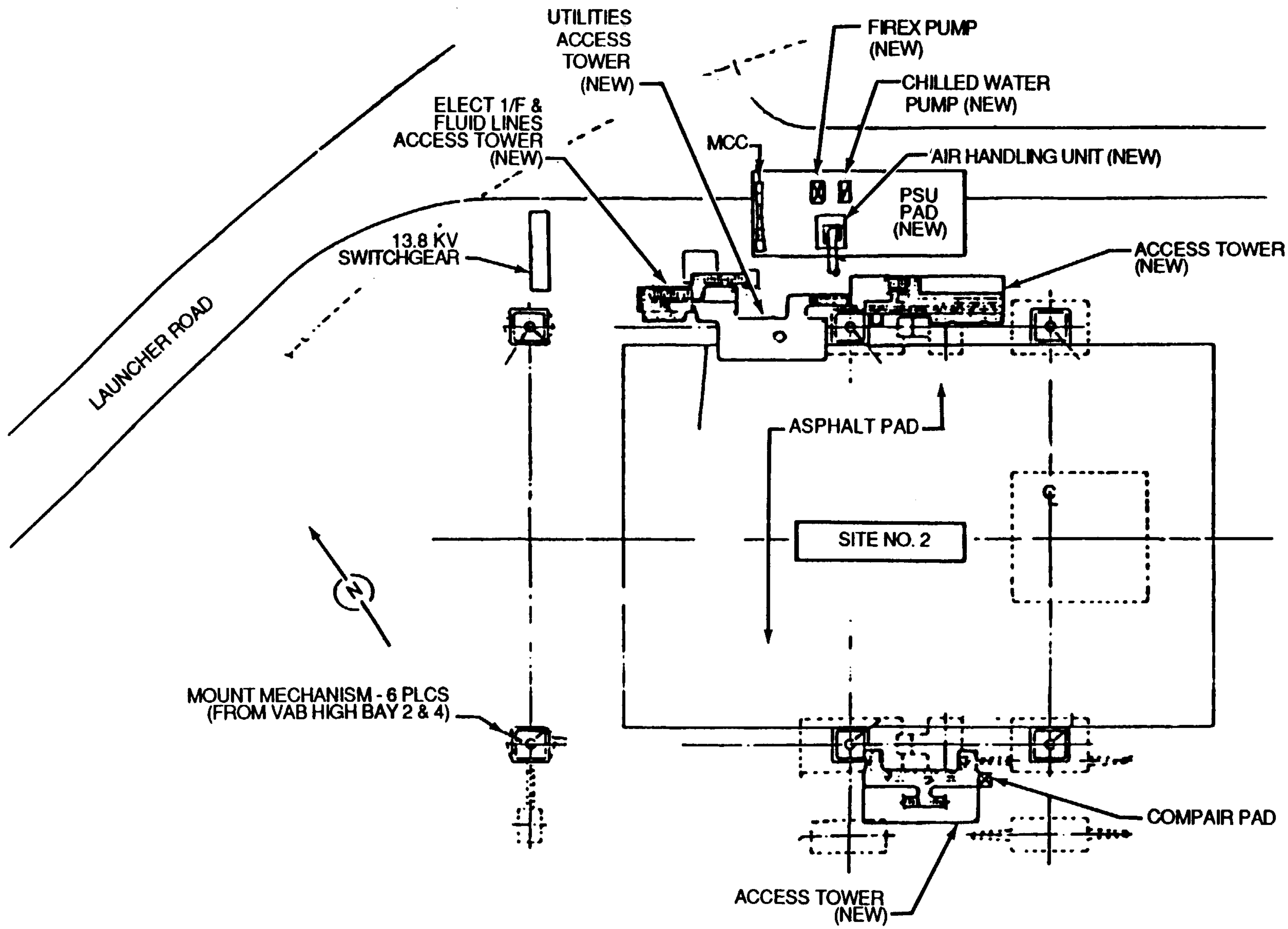
The total ROM cost impact for MLP #5 is $138.8 million for all the LO2/RP-1 configurations, and $153.8 million for the LO2/LH2 pump-fed configuration.

1.8.3 MLP Parksite #2

With the advent of two new LRB MLPs to the existing fleet of three SRB MLPs, additional park-site capability is required. Analysis of the ground processing flow model indicates that one additional parksite, in companion with the two existing parksites are sufficient to support a fleet of five MLPs. This is based upon a nominal MLP post launch refurbishment and pre-stack setup duration of six working days.

MLP Parksite #2 was de-activated in 1983. The foundations for the MLP mount mechanisms remain, as well as the crawlerway. Initially, this parksite will be a dedicated construction site for one of the new LRB MLPs. This will require reinstallation of the mount mechanisms and availability of ground power. During the activation phase and subsequent processing of LRB MLPs, the parksite requirements are more sophisticated. These include installation of access towers, communication systems, and various mechanical utilities. Figure 1.8.3 displays the proposed configuration for MLP Parksite #2.

Design requirements are relatively simple. Existing parksite engineering will be "washed off" and packaged. This can be accomplished in approximately 3 months by A&E or sustaining engineering.



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Figure 1.8.3. MLP Parksite #2 Site Plan

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Implementation, by single fixed price contract, is a 9 to 12 months task, with completion currently planned to support the start of construction activity for MLP #4. The total ROM cost associated with reactivation of MLP Parksite #2 is $3.0 million.

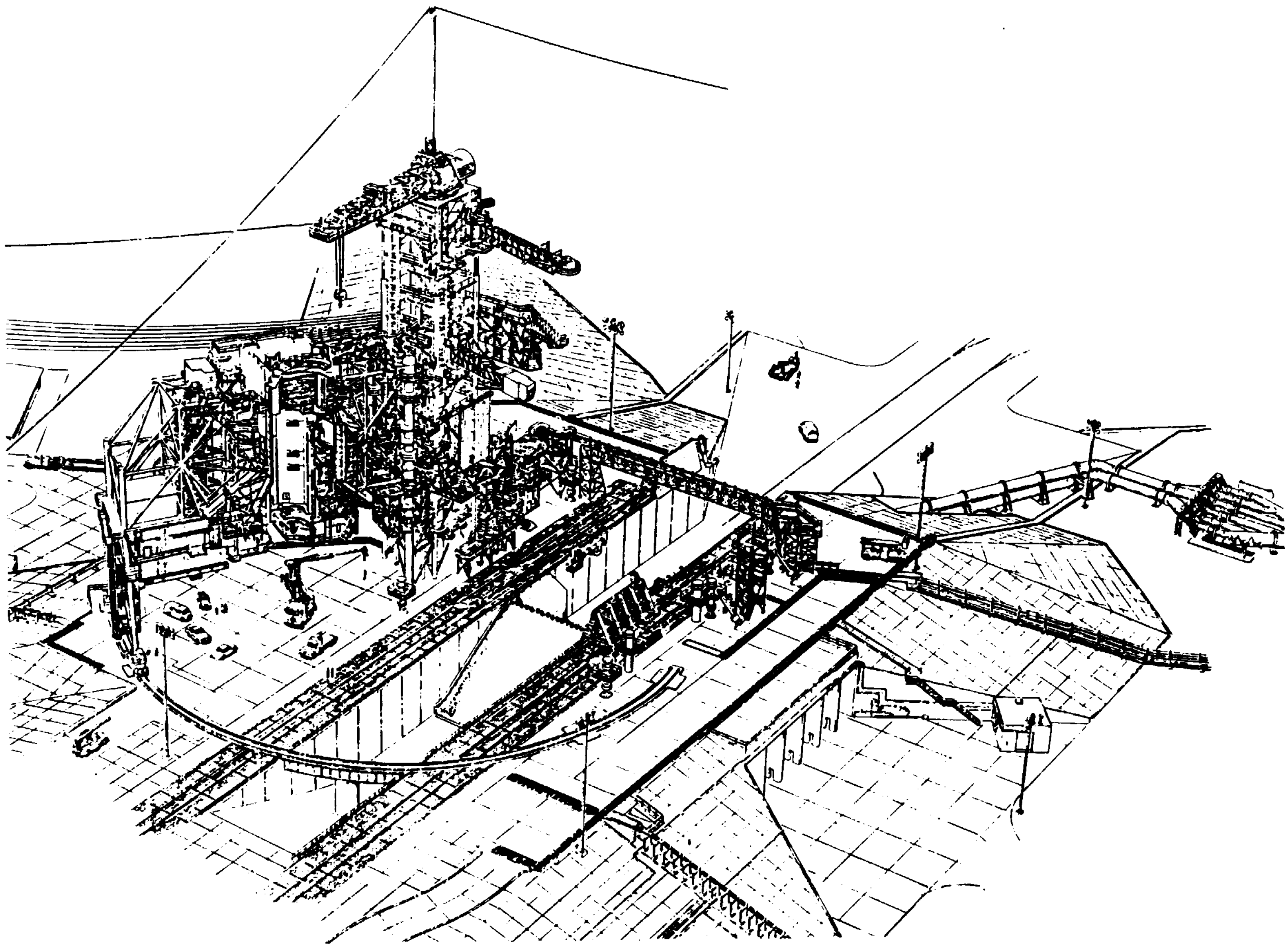
1.9 LC-39 PAD B

Conversion of the LC-39 Pads A and B station sets to LRB/STS capability, imposes the greatest technical and programmatic schedule risks in the scope of LRB activation at KSC. Design is challenged by the constraint of maintaining SRB/STS launch capability. Schedule challenges are associated with maintaining the STS program flight rate while modifying an operational launch pad. To minimize these risk factors, the engineering solutions must be unique and compatible with the proposed implementation concepts. Project planning can be characterized as unconventional, in comparison to recent STS standards.

Extensive modifications are required at the launch pad, and are dependent upon the selected LRB vehicle configuration. These modifications include the addition of new propellant storage and transfer systems, both fuel (RP-1 or LH2) and oxidizer (LO2); replacement of the side and main flame deflectors and probable refurbishment of the existing SRB flame deflectors; removal of the existing ET H2 Vent structure and arm (and GOX Vent Arm for booster lengths above 170 LF) and replacement with a new qualified umbilical; structural modifications to existing SSV access platforms and the Orbiter Weather Protection System; installation of LRB access platforms off the Rotating Service Structure (RSS); and the addition of new pressurization systems for the LRB pressure-fed vehicle configurations. Figure 1.9-1 displays a pad isometric of the current configuration.

The design and subsequent construction services will be procured through multiple A&E contracts and fixed price Davis-Bacon contracts respectively, and packaged based upon the specific engineering disciplines required (ie., Propellants, Deflectors, Umbilicals, Structures, Fluids/Gases). This approach is justified in minimizing schedule risk, and is a trade-off in accepting additional interface control requirements by the Activation Management Team. Each contractor can concentrate on one task, focusing all available resources.

Design is expected to require 24 months total duration, and will proceed upon the availability of preliminary design requirements. The design effort has approximately 21 months of schedule



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Figure 1.9-1. Pad Current Configuration.

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flexibility or float. The current critical path for LRB launch pad engineering is the cryogenic propellant systems.

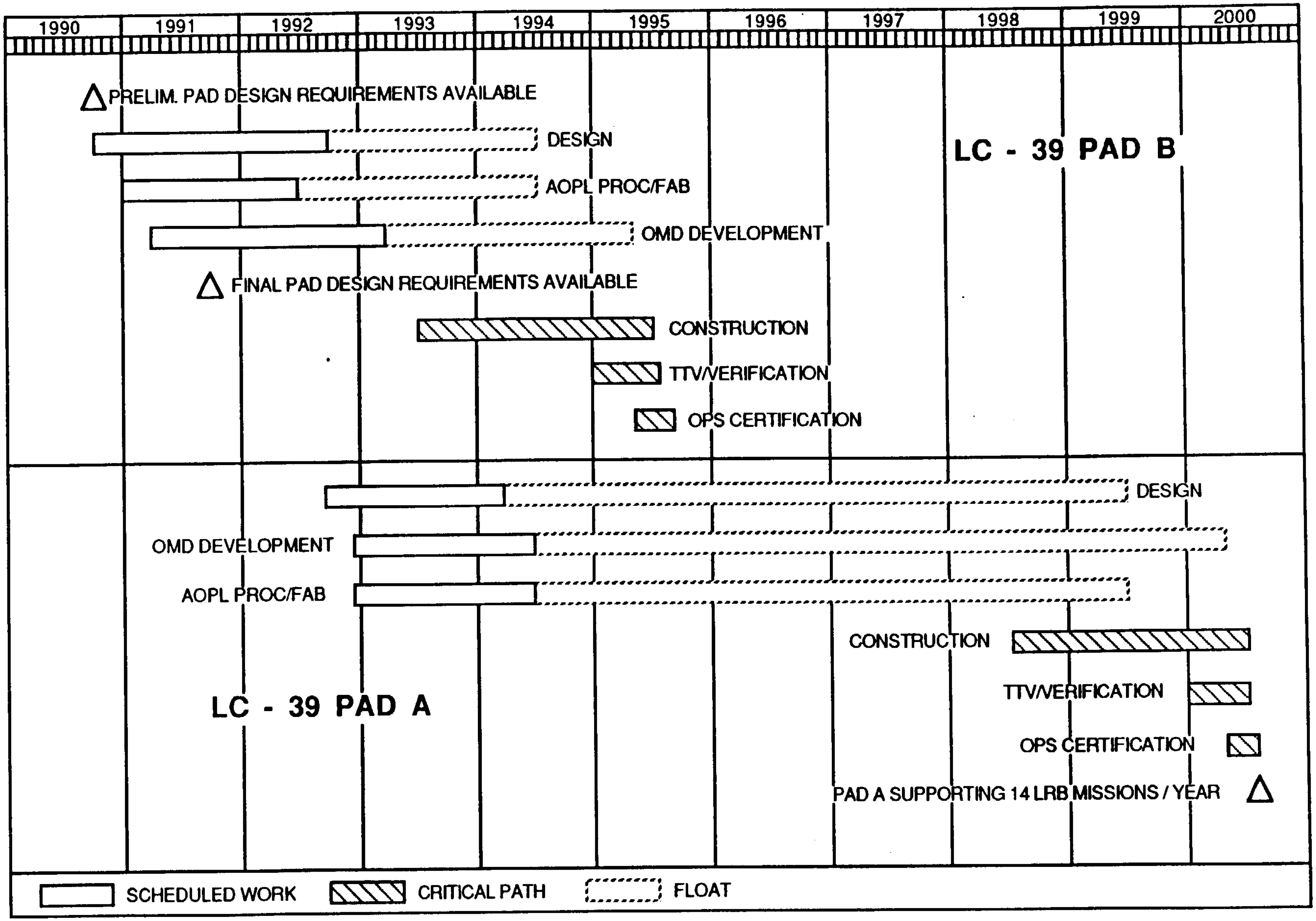
On-site activity will start approximately 26 months prior to ORD. This is a discreet planning decision, to limit the extent of impact by and to the launch pad operations. The initial 18 months of pad access will be restricted, with operations having schedule priority. Approximately 290 out of 540 calendar days are available for modification during this timeframe, with access windows typically 20 calendar days in duration. This imposes additional mobilization and de-mobilization requirements, including launch damage control special conditions. The final 8 months of pad access is unrestricted, with all Pad B operations shifting to Pad A. All on-site activity must proceed on an "around-the-clock" basis. Figure 1.9-2 displays the current conceptual implementation plan for both pads.

The propellant systems can be constructed in 3 concurrent phases; the civil work, the storage spheres or dewars, and the transfer systems respectively. Upon completion of the construction activity, a TTV type contractor will proceed with propellant systems verification followed by operational certification by the SPC. The vacuum-jacketed cryogenic pipe and the transfer system pumps are long-lead items and must be procured in advance. Figure 1.9-3 presents a pad propellant system site plan.

The side and main flame deflectors will be constructed by single fixed price contract. The side flame deflectors can be fabricated and assembled entirely off-site. The main flame deflector will be fabricated off-site by major structural component and assembled in two sections at the north end of the flame trench. Upon availability of unrestricted pad access, the existing SRB main flame deflector will be demolished and the assembled LRB deflector halves will be moved in place by rail for final installation and subsequent sound suppression water system testing.

The ET H2 Vent Structure/Arm and GOX Vent Arm umbilical (if required), will be fabricated under separate fixed price contracts and delivered to the LETF for qualification testing. Upon completion of LETF testing, the umbilicals will be delivered to Pad B for installation by the TTV type contractor, during the final 8 months of pad access.

LC-39 Pad B will support the proposed LRB pathfinder program, LRB ILC and the first 42 LRB STS missions.



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Figure 1.9-2. PAD Implementation Plan.

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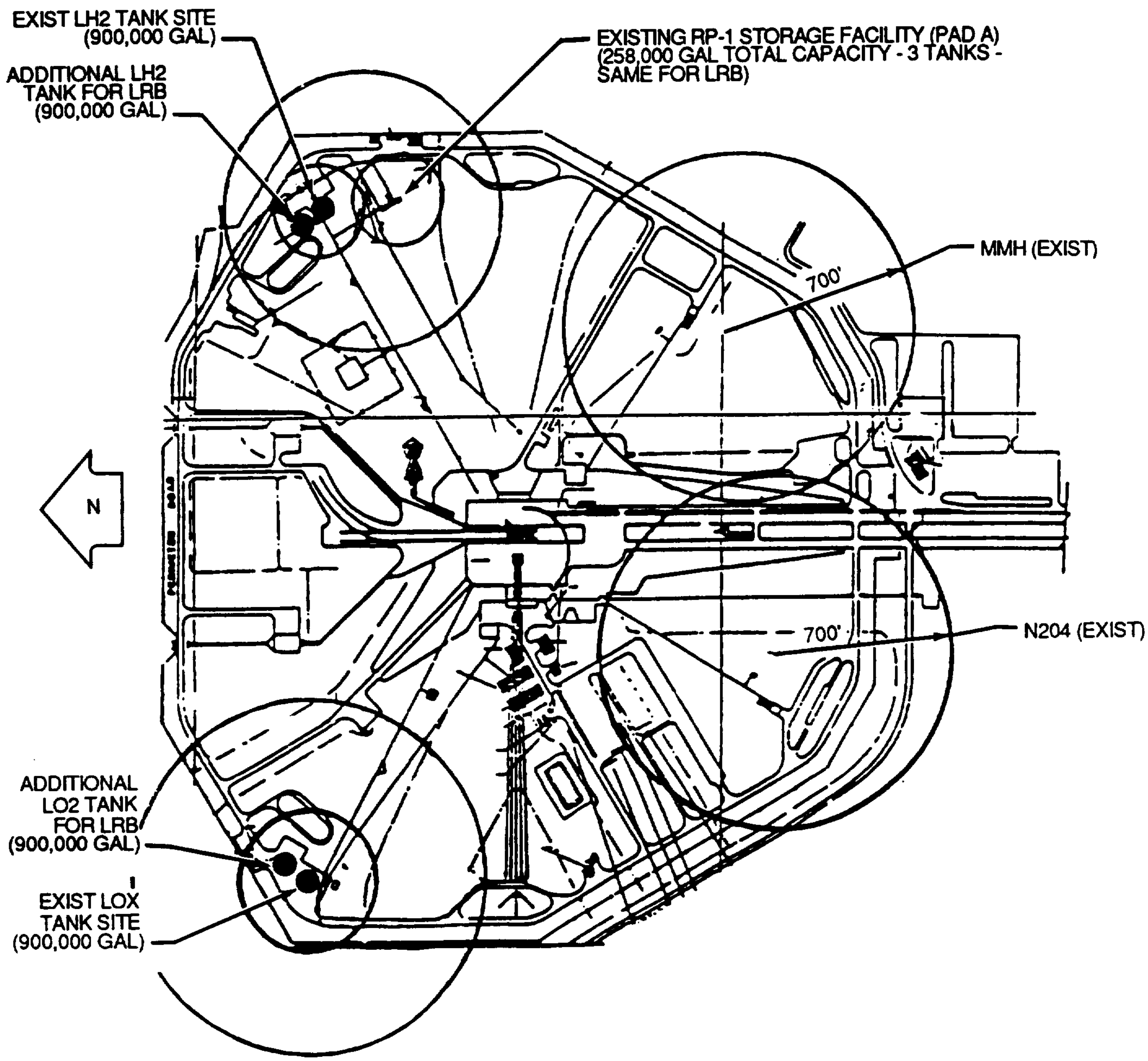


Figure 1.9-3. Pad Propellants Site Plan

The total ROM costs associated with this station set are as follows:

- $81.4 million LO2/RP-1 pump-fed
- $85.2 million LO2/RP-1 pressure-fed (MMC)
- $89.6 million LO2/RP-1 pressure-fed (GDCC)
- $117.2 million LO2/LH2 pump-fed

The significant pad cost discriminators are the addition of pressure system GSE for both LO2/RP-1 pressure-fed configurations; the GOX vent arm modifications and the requirement for additional access structures for the LO2/RP-1 pressure-fed (GDCC) and LO2/LH2 pump-fed configurations; and the additional cost associated with the LH2 storage, handling and transfer system for the LO2/LH2 pump-fed configuration.

1.9.1 LC-39 Pad A

The scope of work and conceptual project planning for Pad A is typical to Pad B. The design requirements are reduced and effectively is a "wash-off" effort of mature Pad B engineering. The implementation requirements are basically identical, with pad access starting in July 1988 to support a June 2000 ORD. The first flight off Pad A is STS-174, the 43rd LRB/STS mission.

LC-39 Pad A costs vary slightly with Pad B, primarily due to a reduction in design costs for the 2nd line facility. The total ROM cost impact for LC-39 Pad A is as follows:

- $79.6 million LO2/RP-1 pump-fed
- $83.4 million LO2/RP-1 pressure-fed (MMC)
- $87.6 million LO2/RP-1 pressure-fed (GDCC)
- $114.5 million LO2/LH2 pump-fed

1.10 LAUNCH CONTROL CENTER (LCC)

Hardware and software impacts to the LCC and Launch Processing System (LPS) have been identified and presented in detail by Volume III Section 3 of this report. This impact analysis is based upon the current configuration of the LCC and LPS. Console and data link requirements are defined, and systems software and applications software upgrades are estimated in quantities of lines of code.

Concurrent with LRB integration at KSC, is a planned major reconfiguration of the LCC firing rooms and extensive upgrade of the LPS, referred to as the Core Electronics System Project. This project is currently under competitive procurement. All information is highly sensitive and proprietary. A blackout period is currently in affect, directed by NASA, prohibiting any communications related to Core, through contract award and Source Evaluation Board (SEB) release of its responsibilities.

The Core Request for Proposal (RFP) requires the Core Electronics Contractor (CEC) provide generic console and subsystem software capability, satisfying goals such as commonality, modularity, standardization and growth capability. Design requirements include the incorporation of maximum flexibility, for potential update and retrofit to accommodate anticipated growth. The CEC will implement and maintain an off-line Software Production Facility (SPF). Upon completion, the SPF will be available for use by the NASA software community. The CEC will establish and maintain interfaces with other shuttle activities in progress or in planning phases.

The Checkout, Control and Monitor Subsystem (CCMS) will be upgraded to a CCMS II configuration. The definition phase for CCMS II is planned to start in the last quarter of calendar year (CY) 1990 and continue through CY 1991. The CEC must be prepared to adapt the CCMS II scope of work to support alternate launch vehicles other than the SRB/STS.

To implement the LRB LCC and LPS requirements, this Phase-A study has assumed that the Core Electronics System Project can provide the LRB console capability based on the aforementioned RFP Statement Of Work (SOW). LRB systems and applications software will be developed at the SPF, either by vendor or the CEC. LRB software development is an approximate 90 man year effort, requiring two years to accomplish. A fiber optics network will interface with the Hardware Interface Modules (HIM) installed at each affected station set. This network will

be procured and installed by single fixed price contract. Figure 1.10 displays the current conceptual implementation plan for the LCC and LPS.

The total ROM cost impact for this station set is $16.5 million, for all LRB configurations. Costs are included for the software development and the fiber optics network only. Costs associated with the LRB LCC console impact have been excluded.

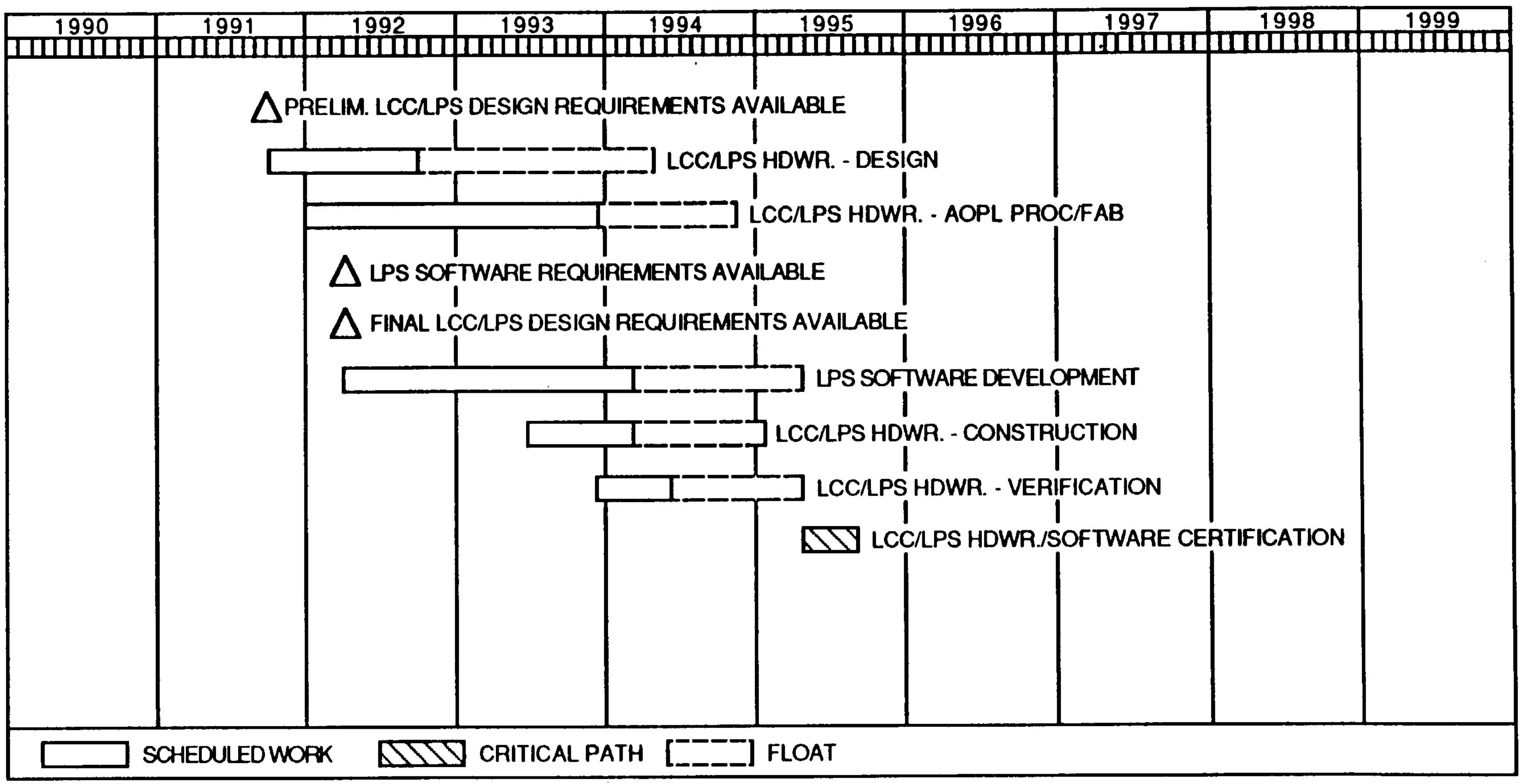
1.11 LAUNCH EQUIPMENT TEST FACILITY (LETF)

The Launch Equipment Test Facility provides KSC with the ability to qualify and certify all operational Launch Support Equipment (LSE). This facility offers LSE testing, by simulation, of vehicle motion prior to launch, at lift-off and during fluid flows. The LETF also verifies the systems for operational performance, emergencies, holds and other contingencies.

All Liquid Rocket Booster (LRB) LSE will undergo qualification and verification as stated above at the LETF. This will be under the guidance of NASA Design Engineering (DE) and the Launch Accessories Contractor (LAC) responsible for the hands-on activities at the LETF. The LRB Activation Management Team will furnish all Launch Support Equipment, appropriate schedules and test requirements documents to the LAC through the defined NASA DE interface.

The facility impacts to the LETF include the addition of test fixtures and interface simulators for LRB LSE qualification testing. An additional structure may be required for the existing LETF umbilical tower to provide access to the Random Motion Simulator (RMS). Modifications to the existing ET/Shuttle simulators may be required. Figure 1.11-1 is a LETF isometric, and displays the current configuration. It is anticipated that the LETF modification time, to support all aspects of LRB LSE testing and qualification will be 8 to 10 months.

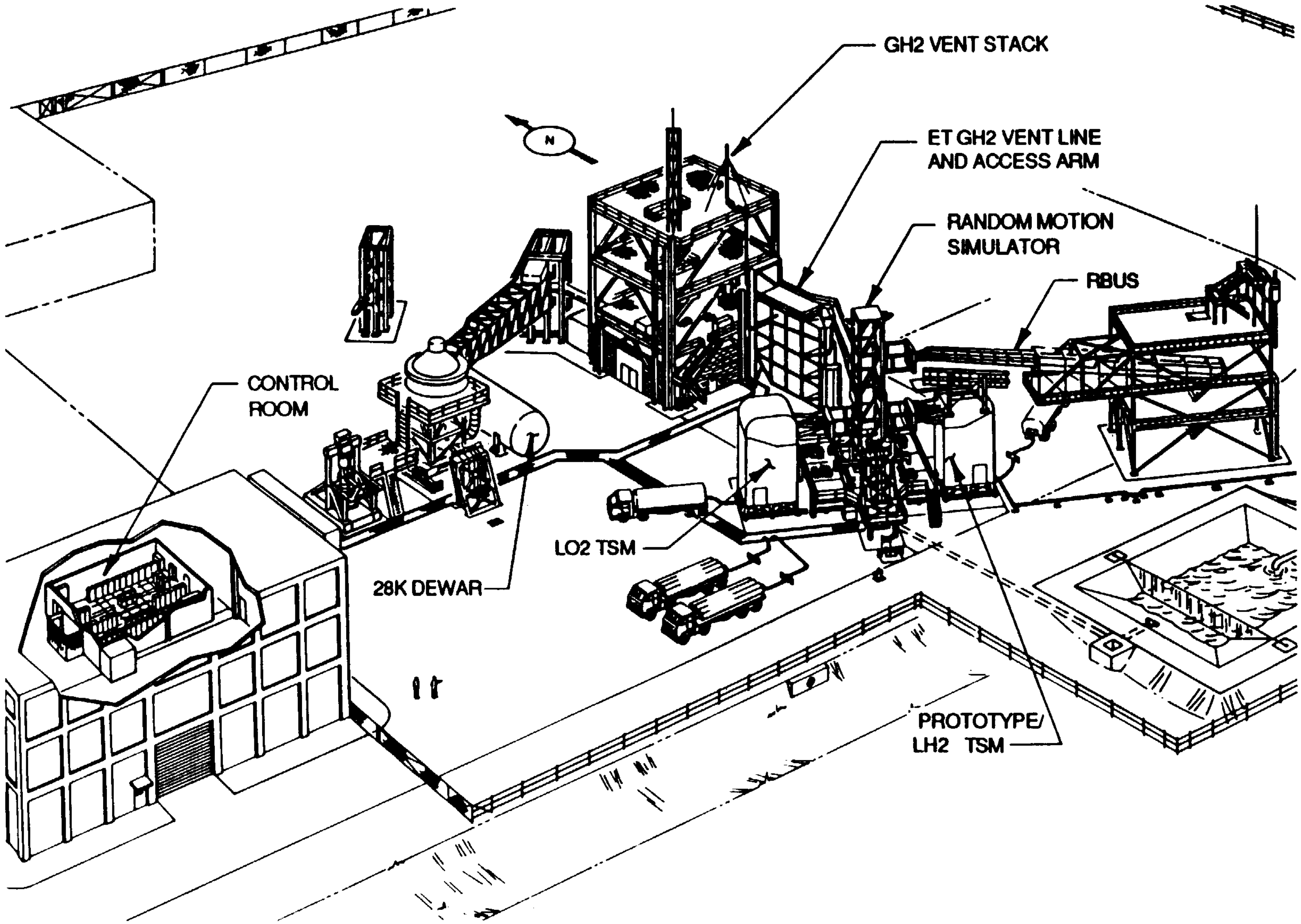
The LRB LSE currently identified for LETF testing is shown in Figure 1.11-2 for all vehicle configurations. This is a preliminary list, pending availability of final vehicle excursion data from Johnson Space Center (JSC). All LSE will be new in lieu of modifying existing hardware. Program schedule requirements dictate this approach. Projected launch pad modification windows are insufficient and MLP modification windows do not exist. The LSE will be designed and fabricated under separate fixed priced contracts and delivered to the LETF for acceptance by the LAC. Upon completion of qualification testing, the LAC will prepare and deliver the LSE to the appropriate station set for installation by others. The LETF qualification testing program will require



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Figure 1.10. LCC/LPS Implementation Plan

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Figure 1.11-1. LETF General Layout.

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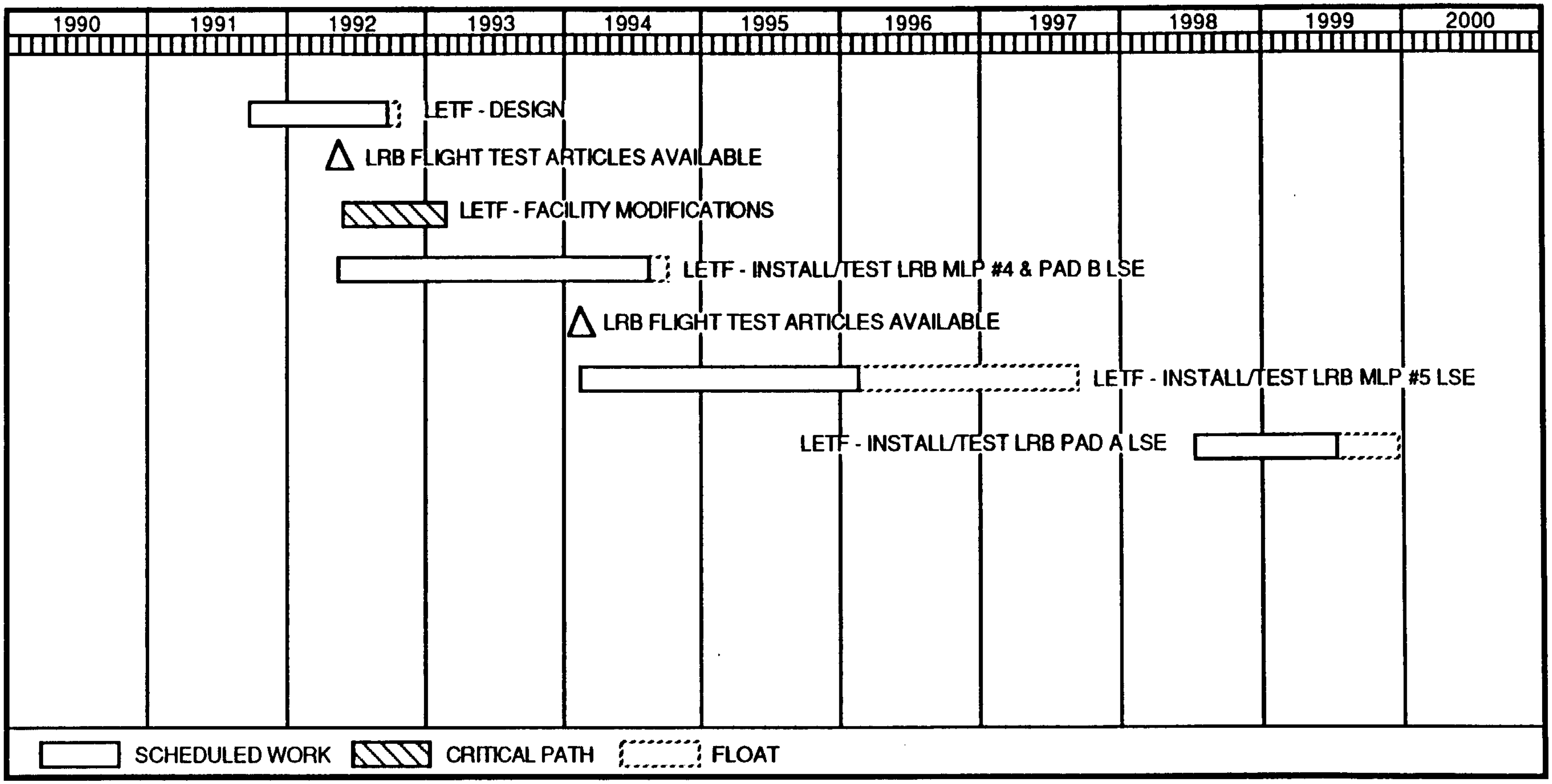
LETF QUALIFICATION TESTING REQUIREMENTS					
LRB OPTION / LSE	MMC LO2 / RP-1 PUMP	MMC LO2 / RP-1 PRESSURE	GDSS LO2 / RP-1 PUMP	GDSS LO2 / RP-1 PRESSURE	GDSS LO2 / LH2 PUMP
NEW LO2 TSM (2)	X	X	X	X	X
NEW LH2 TSM (2)	X	X	X	X	X
NEW HOLDDOWN MECH. (16)	X	X	X	X	X
NEW ET GH2 VENT LINE AND SWING ARM (2)	X	X	X	X	X
NEW ET GOX VENT ARM (2)				X	X
NEW LO2 T-O UMB FOR EACH LRB (4)	X	X	X	X	X
NEW LH2 T-0 UMB FOR EACH LRB (4)					X
NEW RP-1 UMB FOR EACH LRB (4)	X	X	X	X	
NEW POWER/INST. UMB. FOR EACH LRB (4)	X	X	X	X	X

Figure 1.11-2. LETF LSE Testing.

24 months each, for first and second line facility LSE. Figure 1.11-3 reflects the current LETF conceptual implementation plan.

It is probable, that during the time frame required for LRB LETF qualification testing, other STS programs will concurrently impose demands on the LETF resources. Depending upon the scope of these programs and the respective program schedule flexibility, LETF capability may have to be significantly expanded. Lacking definitive alternate STS program (s) visibility, this Phase-A study has not addressed this scenario in terms of cost, resources and schedule.

The total ROM cost impact for LRB LSE qualification testing at the LETF is $23.1 million for the LO2/RP-1 pump-fed and LO2/RP-1 pressure-fed (MMC) configurations; $26.1 million for the LO2/RP-1 pressure-fed (GDCC) configuration; and $33.4 million for the LO2/LH2 pump-fed configuration. The significant price discriminators are the requirements for GOX Vent Arm certification for the LO2/RP-1 pressure-fed (GDCC) and LO2/LH2 pump-fed configurations; and certification of the LH2 T-O lift-off umbilical for the LO2/LH2 pump-fed configuration.



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Figure 1.11-3. LETF Implementation Plan.

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VOLUME III

SECTION 2

LRB PROCESSING TIMELINES

VOLUME III SECTION 2

LRB PROCESSING TIMELINES

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LRB PROCESSING TIMELINES

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SECTION 2

LRB PROCESSING TIMELINES

2.1 GROUNDRULES AND BACKGROUND

The Study Team formulated a series of LRB processing tasks based on previous experience of STS booster operations at KSC and prior activities in the processing and launch of liquid fueled vehicles. These tasks were evaluated as to duration and hands-on manpower requirements. The tasks were then scheduled in a logical sequence which was merged with existing STS integrated processing. This networked CPM was then loaded into the ARTEMIS computer system producing the LRB timelines and task sequencing. This processing model facilitated identification of critical path elements and the assessment of manpower requirements.

The groundrules established for this timeline assessment included:

- Standalone booster processing activities were to be performed offline to the integrated STS flow and should result in the flight certification of the booster system prior to MLP mate.

- Since the launch site scenario depicts booster arrival by barge, the normally accepted pre-launch testing and certification requirements are required to be performed. If future considerations place final assembly in the area of VAB operations some refinements and task eliminations should be considered.

- All timeline developments, facilities and processing activities support an initial launch capability in FY96 to begin the five-year planned transition launch rate ramp of 3, 6, 9, 12, 14 to FY2000.

- Second line activations during transition are planned to support this launch rate build-up and to achieve a life cycle mission profile of 122 LRB missions by end of FY2006.

2.2 DETAILED LRB PROCESS FLOW (LOGIC DIAGRAM)

Figures 2.2-1, -2 and -3 present the logic flow diagrams of all LRB unique tasks in an assessment of all processing activities including hardware delivery, standalone checkout, integrated operations and launch pad processing required in the planned LRB ground operations. Key activities associated with STS processing are noted in the flow for reference along the bottom of each chart. The upper band on each chart lists tasks associated with facility and GSE preps and the central band(s) present LRB processing tasks. The task duration in shifts is noted in the lower right corner of each task box and the highlighted boxes represent the assessed critical path through each phase. The phases of activity covered by each of the three figures is as follows:

Figure 2.2-1 LRB Horizontal Processing Facility (HPF) Flow Diagram

Figure 2.2-2 LRB MLP/VAB Processing Flow Diagram

Figure 2.2-3 LRB Pad Processing Diagram

For a summary of these LRB timelines see Section 2.4 below. These timelines have been designed to support the launch site processing of the "baseline" pump-fed LOX/RP-1 LRB configuration. Only slight task modifications would be required to apply these timelines to the other propellant (LH2) or to the pressurized LRB configurations. These changes would not result in significant timeline or manpower changes.

2.3 KSC FLOW MODEL

This "KSC Flow Model" produces a "facility level" STS ground turnaround processing plan with an optimized launch rate based on, a given cargo manifest, selected facilities available, assigned processing times and work schedules, and established groundrules. The plan is built within an Artemis network. Changing cargo manifest, facilities available, processing times and groundrules provide alternate options for comparison.

The model is limited to "major facility/major process" level of detail relative to utilization of facilities, and to time units of not less than one day. The plan includes KSC launches, and Orbiter modification and/or inspection periods.

Tables, listings and bar charts are used to present planning data contained in the project network. Special features in the "Model" permit manual addition of STS flights requiring unique KSC processing activities and/or sequencing, and use of the "Model" as the basis for generating a "one time" plan that can deviate widely from normal groundrules. Output reports can be altered to fit any particular requirement.

2.3.1 Processes and Facilities

The "KSC Flow Model" network contains facilities, dates, durations and work shift assignments for the following major processes:

- Booster build-up
- Surge Storage
- SRB stack
- ET checkout
- ET storage
- ET mate and SRB closeout
- OPF
- Orbiter mate in the VAB
- Pad
- Launch
- Mission
- MLP and Pad refurbishment
- DFRF landing
- Orbiter modification and inspection

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Any or all of the following facilities may be included in the "KSC Flow Model" planning network. (proposed new facilities may be included to provide a broader range of options)

- Orbiters - 102, 103, 104, 105
- OPF - 1, 2, 3
- VAB/HB - 1, 3, 4
- PAD - A, B, C
- RPSF - 1, 2
- SURGE - 1, 2, 3, 4
- ET Cells - 2, 4
- MLP - 1, 2, 3, 4
- OMRF - 0, 1

2.3.2 Variable Input Parameters

Following is a list of the facilities and variable input parameters that must be selected at the start of building each "KSC Flow Model" network:

- Orbiters
- RPSF
- Surge Facilities
- ET Checkout and Storage Cells
- MLPs
- VABs
- OPFs
- Pads
- OMRF
- % DFRF landings (0%, 20%, 50%, 100%)
- Number of work days required for each process
- Work Shift assignments for each process (5/2, 5/3, 6/3, 7/3 with or without holidays)
- STS flight number (first and last flight in plan)

For a series of similar option networks, intended to show the effects of changes in one or several of the parameters, the following variable parameters can be held constant;

- Flight manifest (launch order list)
- KSC launch cargoes
  - KSC launch window cargoes
  - Orbiter Mod & Inspection periods
- Cargo up/down processing impacts
- Planned reductions in work durations
- Time interval between launches

2.3.3 Model Groundrules

Following is a list of the current standard groundrules (constraints) observed in building a "KSC Option Model Network";

- Orbiters and facilities are assigned on a "first available, first used" basis. The VAB high bay selected determines which ET cell is used.

- Cargo/payload are assigned in the sequence listed in the manifest. If the next Orbiter available is not compatible with the next cargo, ARTEMIS proceeds down the manifest until a compatible cargo is found and inserts it is as the next flight.

- STS flights that require specific launch windows are inserted at the appropriate time to meet the window requirement.

- Surge facility is required the final 8 days of booster build-up and the first 8 days of SRB stack.

- VAB overhead crane is required for the following events;

  - SRB stack, except for final three days.
  - First day of ET checkout (includes moving completed ET to storage cell if necessary).
  - First day of ET mate.
  - First day of Orbiter mate. (Only one of these activities is allowed to occur at a time.)

- VAB high bay and MLP are required for 2 days of preps before SRB stack can begin.

- MLP cannot be moved into VAB high bay the same day as roll-out to the Pad.

- ET checkout/storage cell #2 supports stack in VAB high bay #1 and checkout/Storage cell #4 supports VAB high bay #3 only.

- Vehicle movements are included in the first day of an activity, e.g. rollout to pad is part of the first day of Pad processing.

- OPF flow starts 6 days after landing at DFRF.

- The day the Orbiter lands at KSC after a mission or ferry from DFRF, is also the first day of OPF processing. The first day in the OPF can be any day regardless of weekends or holidays.

- Orbiter is assumed to leave the OPF immediately after completion of OPF processing to make the OPF available for the next Orbiter.

- Orbiter mate cannot start until 4 days after start of ET mate, at the earliest.

- If Orbiter mate occurs before ET mate/SRB closeouts are completed, 1 day is added to ET mate/SRB closeout duration.

- Launch is not planned for Saturday or Sunday except as required for specific launch windows.

- Minimum intervals between launches are as follows;
  - 14 days after launch that lands at KSC.
  - 18 days after launch that lands at DFRF.
  - 35 days between DOD launches.

- Launch day is the first day of the mission and not included in Pad processing time.

- Orbiter modification and inspection periods require an OPF prep period of at least 6 days when using the OMRF, or may be performed entirely in an OPF, if available.

- If OMRF is not ready to accept Orbiter for mod & inspection at completion of OPF safe/deservicing, the mod & inspection is postponed until the next cycle of that Orbiter.

- Mod & inspection periods are inserted between flights to minimize the time an Orbiter will sit idle waiting for a facility.

- If two or more modification and inspection periods are required so close together that at least one mission cannot be flown between them, all modification and inspection requirements involved will be planned to be performed concurrently and given a duration of the longest modification and inspection period included.

- Coast-to-coast ferry flights are planned to require 2 days.

2.3.4 Multiflow Baseline Flows For STS/SRB

For the purposes of the development of our baseline STS multiflow model the following additional groundrules and timelines were used.

- The near term (March 88) manifest launch dates through Mission STS-77 (Sept 93) were merged with a continuing 14 - 15 nominal annual launch rate format to generate missions from FY 1991 through FY 2006. This model covers approximately 224 missions in this total period. (See Volume V, Appendix 2, Figures 2.4-1 through -11 for the March 1988 Baseline Manifest.) Another Manifest was released in August 1988 and an update in October 1988.

- Orbiter fleet size increases to 4 with the introduction of OV-105 with an ORD of 31 May 1991. OPF 3 has an ORD of May 1993 making 3 full OPFs after that date.

- OV-102 carries no DOD payloads, all other Orbiters can carry all payloads.

- Minimum launch interval is 14 days; for DOD-to-DOD missions it is 35 days.

- Launches are scheduled only on week days (Monday through Friday) to avoid undue weekend overtime. After Mission STS-77 50% of the Orbiter landings are scheduled at DFRF and 50% at KSC; until then all are at DFRF.

- Major modification and structural inspection intervals for the Orbiter fleet are incorporated on 2 year, 3 year, 4 year and 6 year intervals.

- After STS-77 (Sept 93) standard processing timelines are assessed in workdays as follows;

  OPF = 51
  VAB = 5 (after Orbiter mate)
  Pad = 18
  ET processing = 20
  RPSF (aft booster build-up) = 23
  SRB stacking = 21 (Later assessments forecast stacking times of 24 workdays)
  ET/SRB mate and closeout = 11

The resulting ARTEMIS derived multiflow processing activities are presented in the 6 pages of Figure 2.3.4-1 through Figure 2.3.4-6 entitled "Facility Planning Chart".

A closeup view of a typical mid - 1995 mission processing flow taken from this model is shown in Figure 2.3.4-7. Here comparable LRB timelines are darkened-in over the appropriate regions and LRB reductions (in work days) are noted. A SRB/LRB integrated flow comparison is presented in Figure 2.3.4-8. Reduced demand on launch site facilities can be seen in these comparison timelines.

2.3.5 Multiflow Utilization Timelines (ET/SRB)

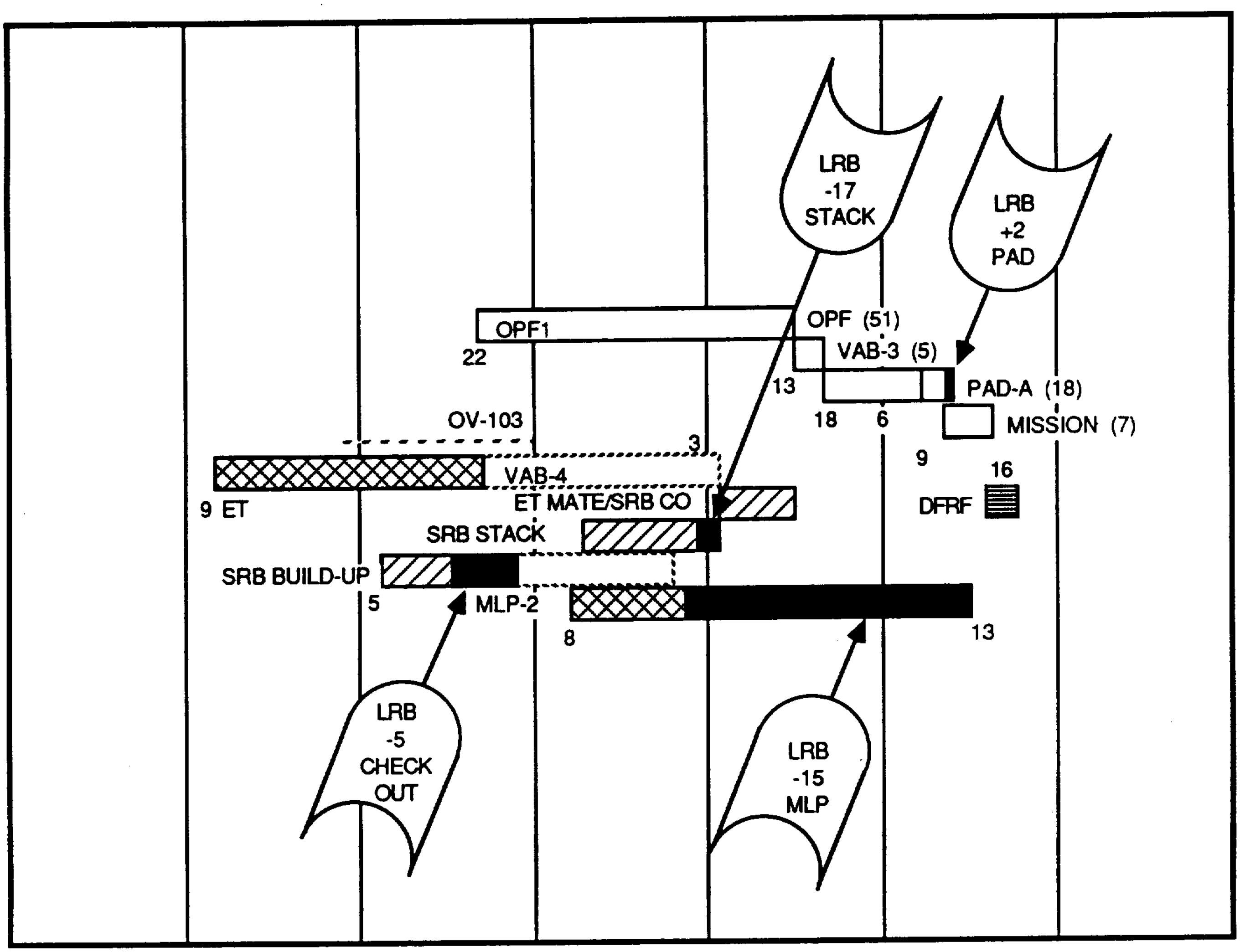
The baseline ET/SRB Facility Utilization charts (16 pages) which match the multiflow baseline flows presented in Section 2.3.4 are presented in Volume V, Appendix 2, Figure 2.1-1 through -16. The facility use is displayed for:

- ET Cells 2 and 4 - Checkout cell time is shown cross-hatched. Movements from checkout cells to storage cells is shown as the end of the solid timeline. Storage time is not displayed.

- RPSF - Aft booster build-up activity is shown cross-hatched. Surge use is not displayed.

- SRB Stack - Booster stacking in VAB HB-1 and HB-3 is shown in solid black.

- MLP - MLP-1, -2, and -3 use is shown. Post launch refurbishment is nominally 4 days and pre-stack preps (holddown post alignments) is nominally 2 days. These turnaround times are included in the chart timelines.



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Figure 2.3.4-7. LRB/SRB Facility Planning Comparison

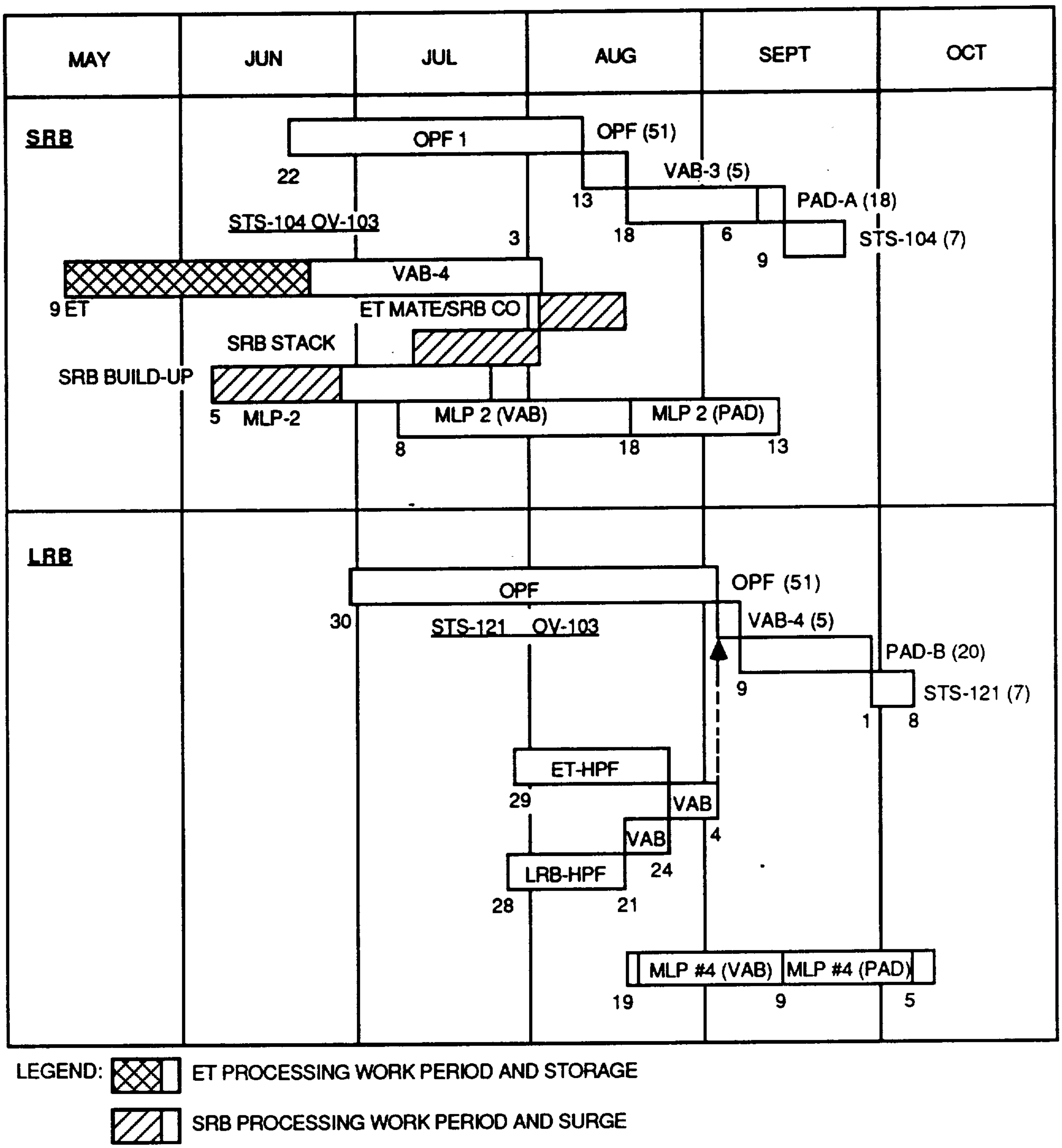


Figure 2.3.4-8. SRB/LRB Comparative Facility Planning Chart For Typical STS Flows.

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- VAB - HB-1 and HB-3 use is shown to support preps, stacking, ET mate and closeout and integrated testing. SRB stacking is shown as heavy black line, ET mate and closeout is shown by diagonals and integrated test is shown prior to VAB rollout to Pad.

2.3.6 Facility Open Periods Timelines (ET/SRB)

In order to focus on available mod periods in both the activation period FY 91 to FY 95 and during the transition period FY 96 through FY 2000 a display of vacant or open periods in each of the ET/SRB facilities was developed. These charts (16 pages) matching the baseline flows of Section 2.3.4 are shown in Volume V, Appendix 2, Figure 2.2-1 through -16. Available MLP times at the full 14 launches per year are significantly limited. This fact motivated our study team's decision to propose all new MLPs for LRB. In addition, VAB HB-1 and HB-3 open periods are very limited. This fact helped motivate our proposed conversion of HB-4 for LRB.

2.3.7 Multiflow Utilization Timelines (Orbiter/SSV)

The baseline Orbiter and SSV Facility Utilization Charts (18 pages) which match the Multiflow Baseline Flows presented in Section 2.3.4 are presented in Volume V, Appendix 2, Figure 2.3-1 through -18. These charts are included mainly for the information contained in the Pad use area. OMRF and OPF uses are displayed for Orbiter flows. VAB/HB-1 and HB-3 are shown as well as MLP-1, -2, and -3. Pad A and Pad B use is shown. These pad timelines were used to assess mod period availability and to evaluate transition scheduling issues as described in Volume III, Study Product 9, Preliminary Transition Plan.

2.4 GENERIC LRB TIMELINE

2.4.1 Detailed Flow

The timeline summary of the LRB detailed processing flow described in Section 2.2 is presented in the 3 pages of Figure 2.4.1-1 through -3. The first figure displays the planned work in the Horizontal Processing Facility (HPF). The second figure describes the VAB flow and integration activity. The third figure presents the schedule of Pad activities for LRB. Significant SSV activities are shown for reference.

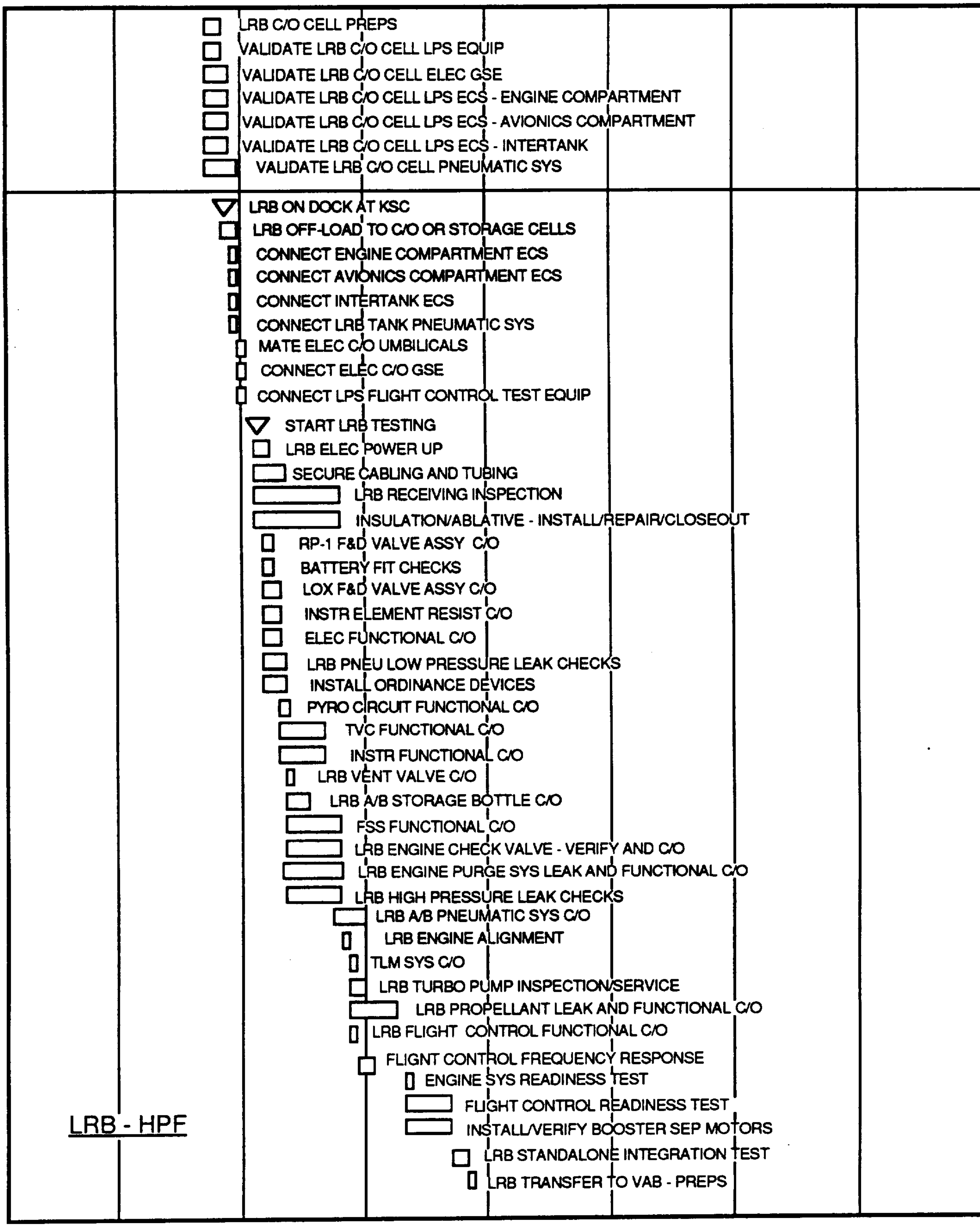


Figure 2.4.1-1. LRB Standalone Processing.

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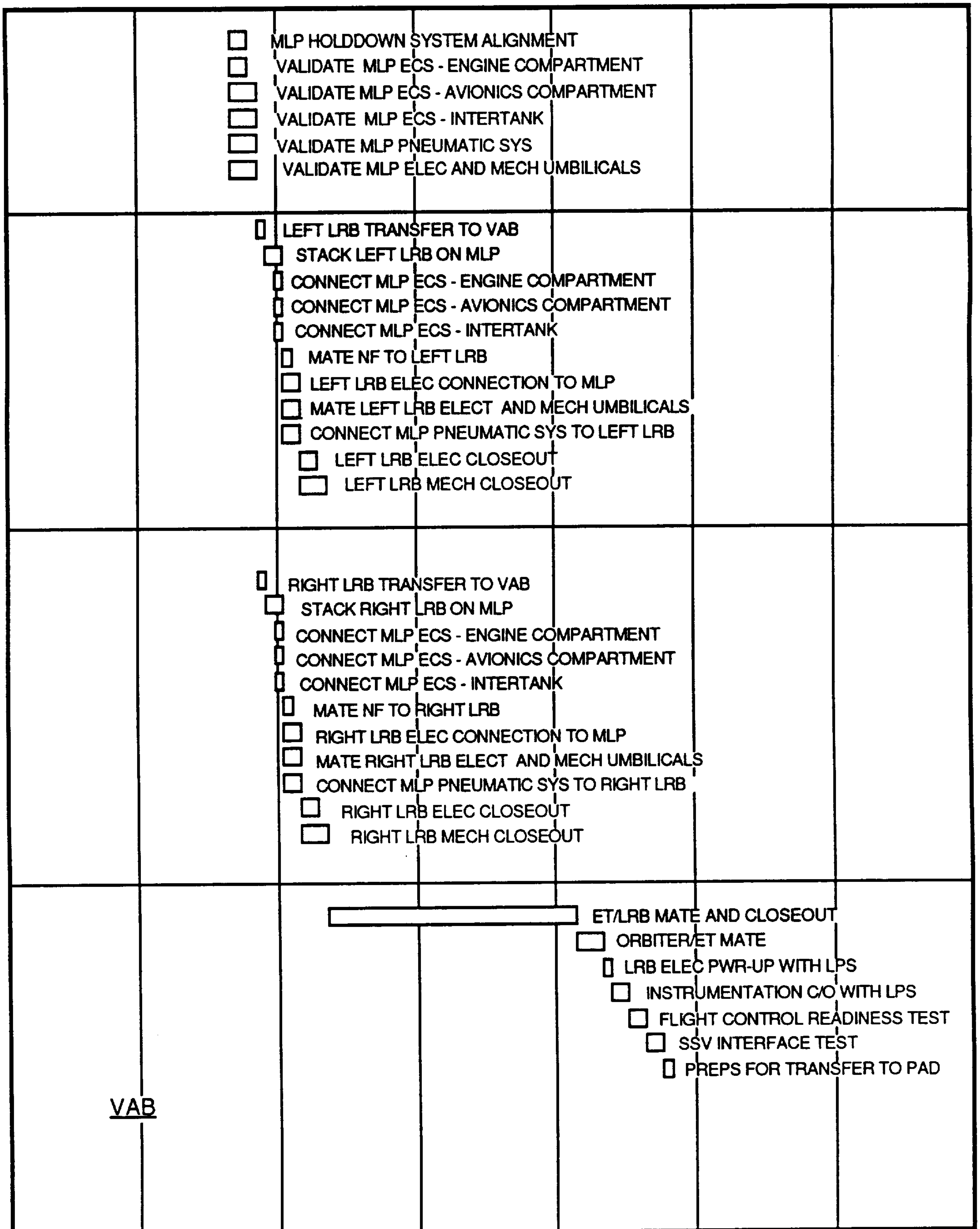


Figure 2.4.1-2. LRB Integrated Processing.

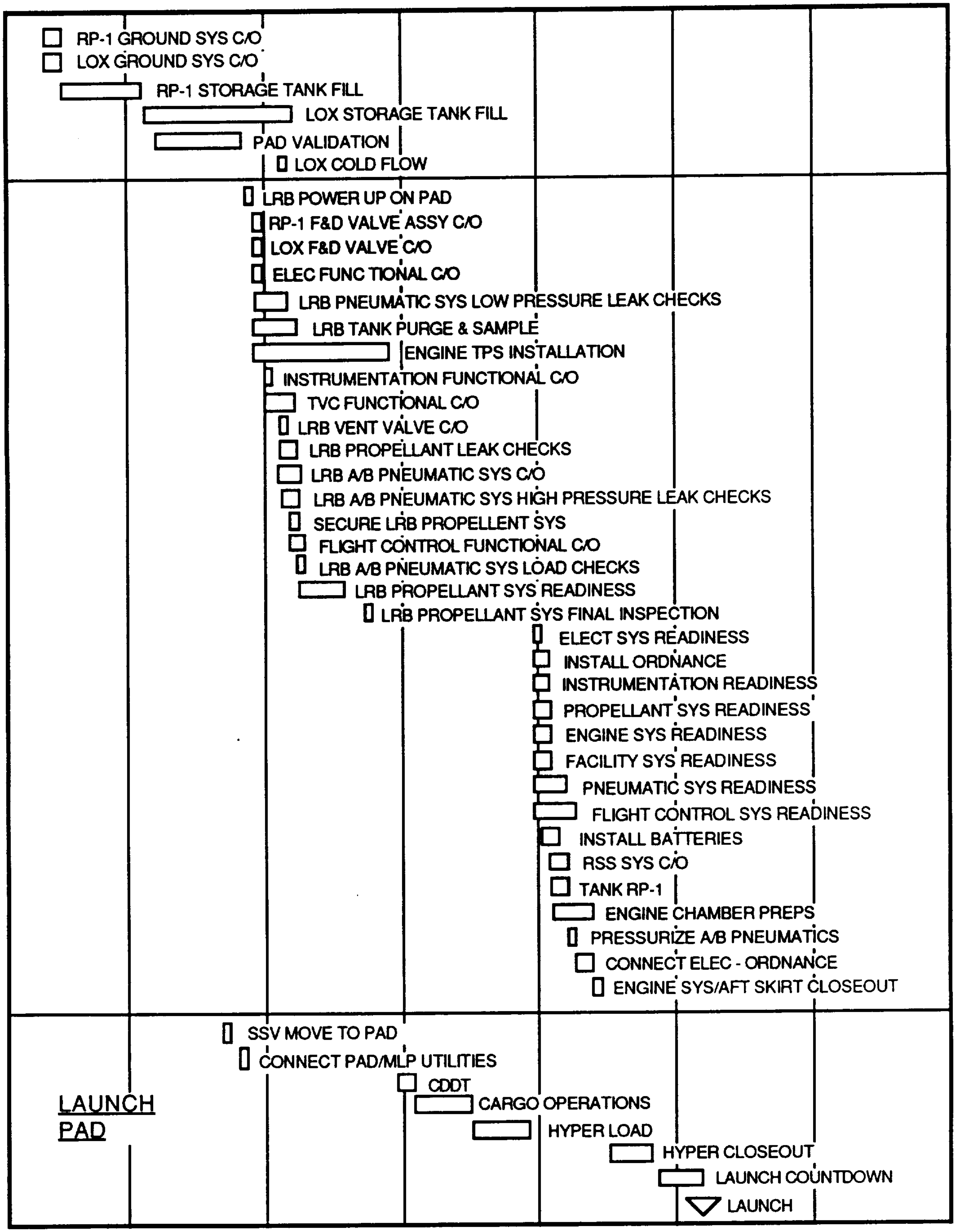


Figure 2.4.1-3. LRB Pad Processing.

2.4.2 Summary Flow

The LRB schedule summary of processing activities from barge delivery to launch is shown in Figure 2.4.2-1. This major summary schedule covers all the detailed tasks in the model described above. The summary schedule was used in the schedule integration activities described in the next section.

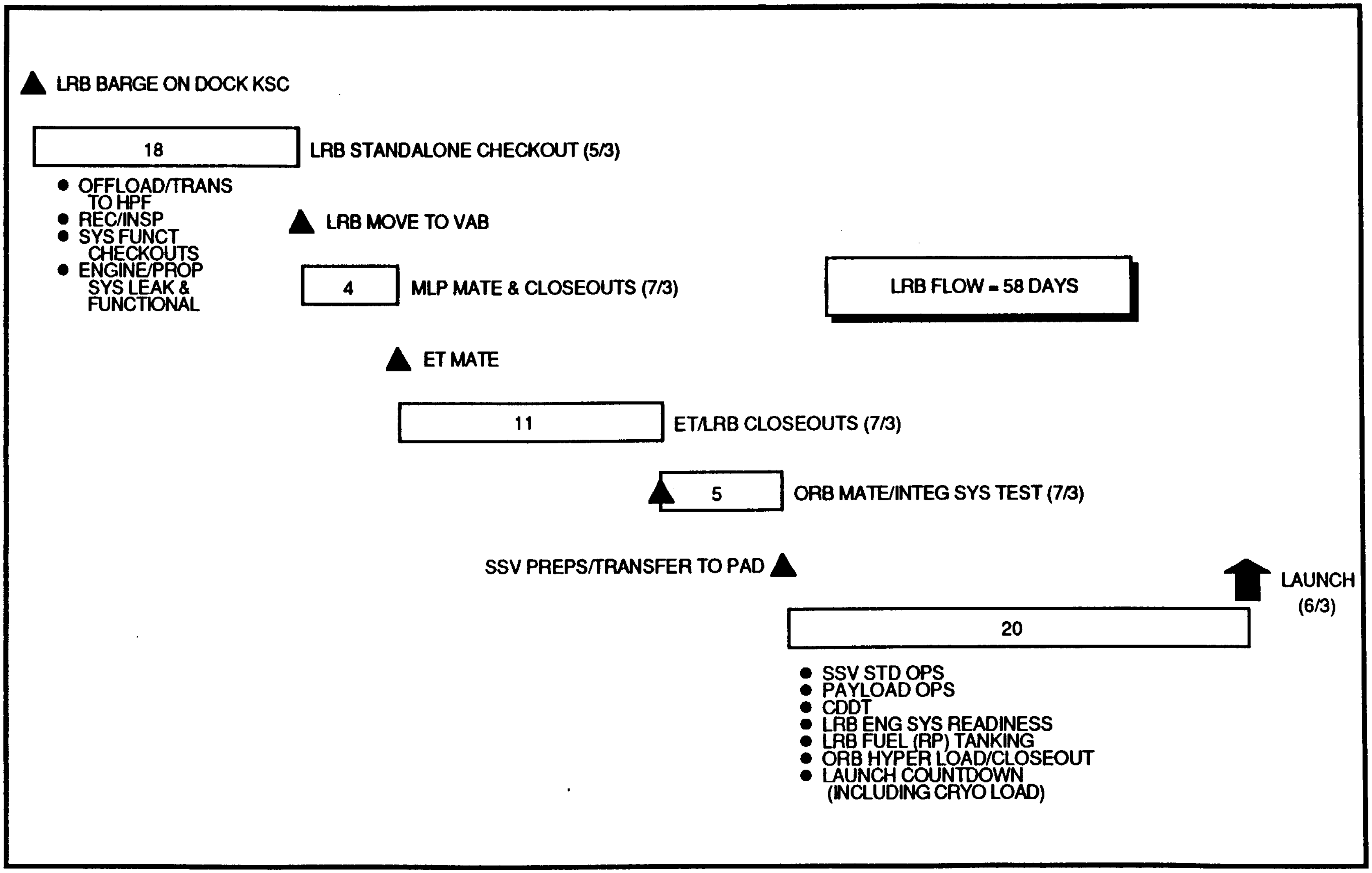
2.5 LRB FIRST THROUGH FOURTH FLOW TIMELINES

Using the STS Baseline flows described in Section 2.3 the Study Team targeted an Initial Launch Capability (ILC) date in early FY 96. This first flow for LRB was identified as STS-111 and was integrated with the multiflow baseline as shown in Figure 2.5-1. Provision was made for a "pathfinder" opportunity and the readiness dates for major LRB facilities were noted on the schedule. The first four missions of LRB were then scheduled so that a conservative length of processing time was allowed in each of the first three missions before achieving the "generic" timelines on the fourth mission (IOC). These first four LRB mission timelines are shown in Figure 2.5-1.

2.6 MULTIFLOW LRB TRANSITION MISSIONS

Using the original KSC Baseline ARTEMIS Flow Model as a worksheet, the remaining LRB transition missions were identified as shown in Figure 2.6-1 and -2. The five year transition launch rate build up of 3, 6, 9, 12, 14 results in a total of 44 missions over the period FY 96 through FY 2000 as shown in the figure. All manifested missions after FY 2000 would also become LRB missions through the life cycle of 122 missions. LRB planning on this worksheet is scheduled to support the 14 - 15 launches per year in the Baseline Flow Model.

LRB processing integration of timelines during the activation and transition periods results in the processing facility utilization charts shown in Figures 2.6-3 through 2.6-13.

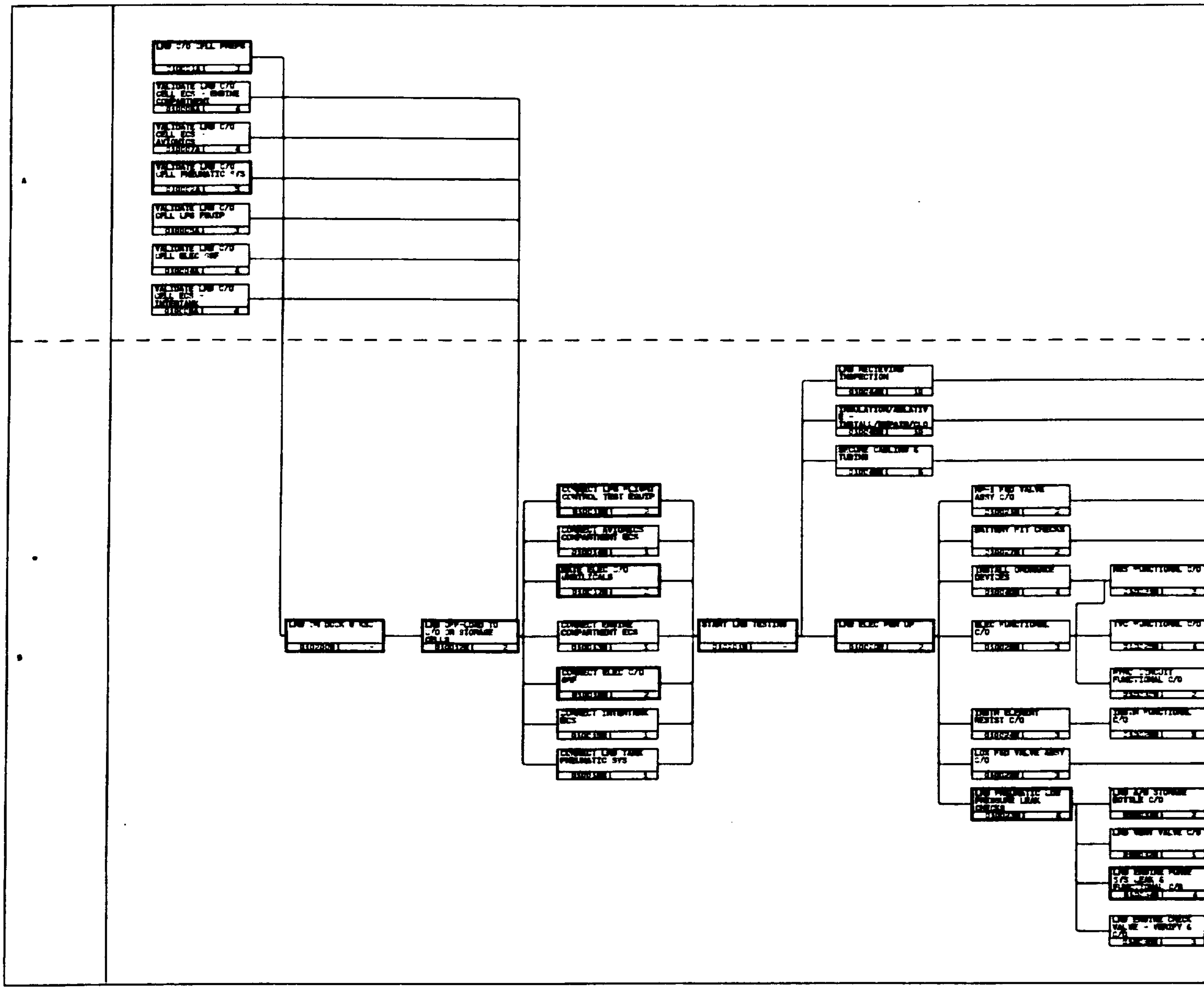


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Figure 2.4.2-1. Generic LRB Process Flow.

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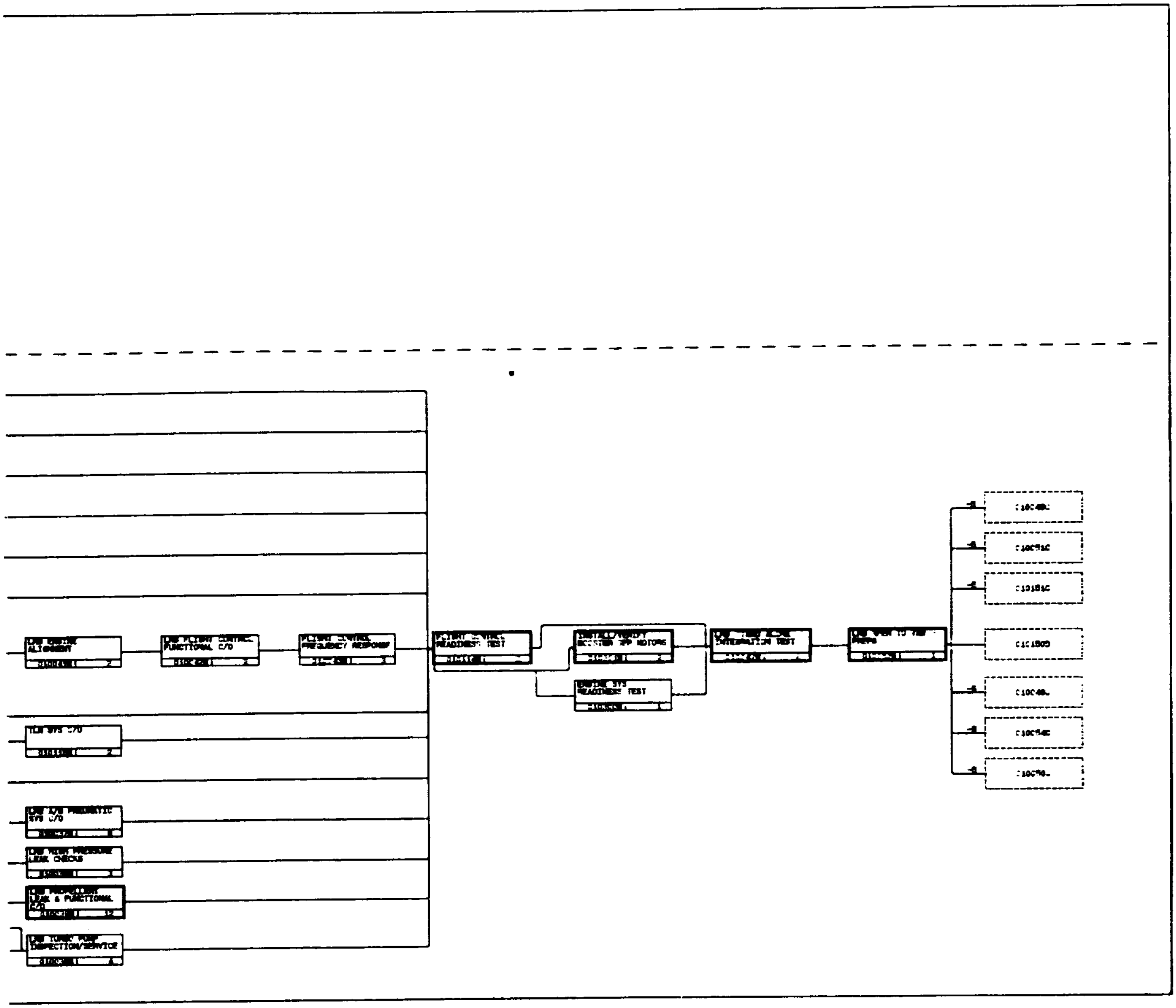
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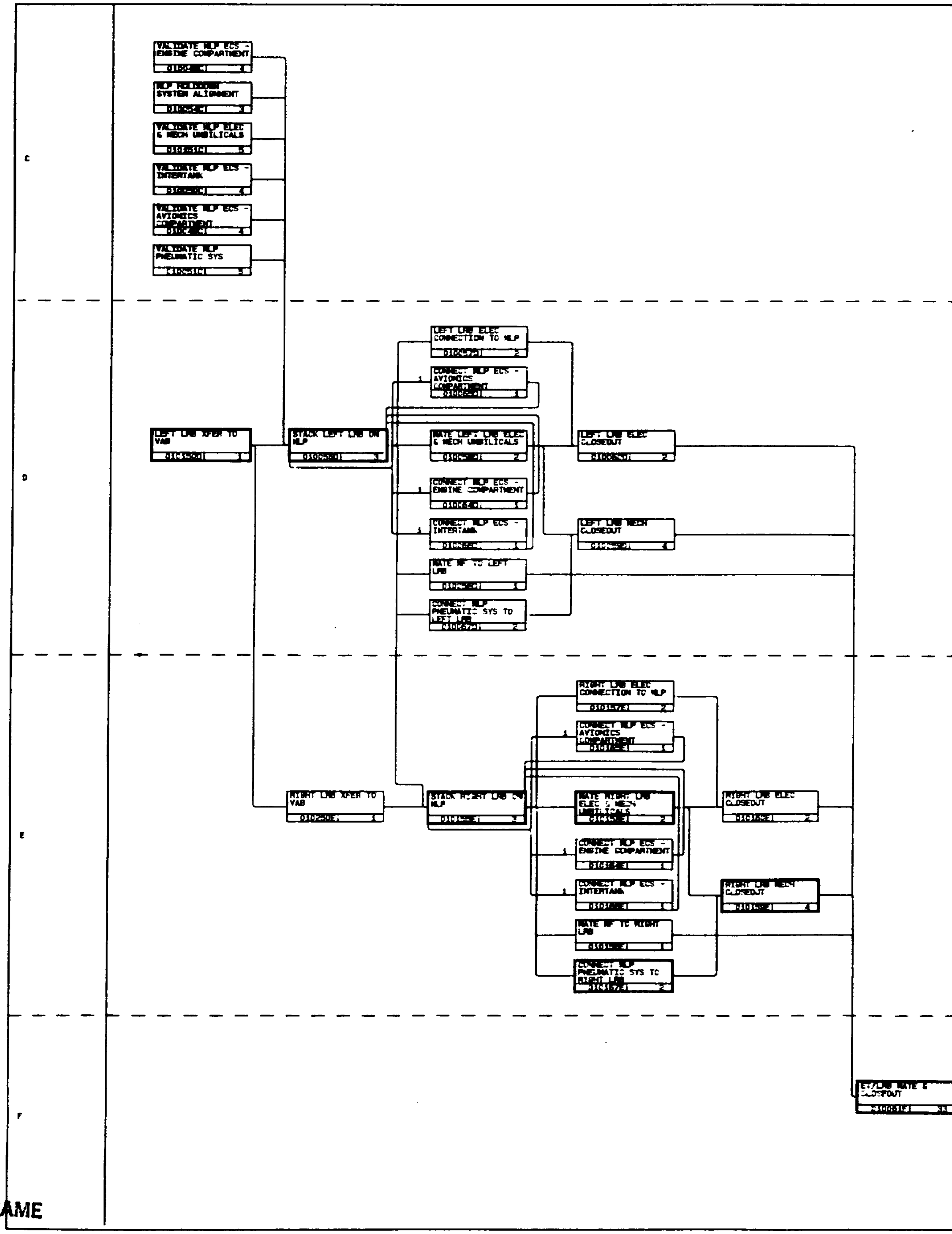
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Figure 2.2-1. LRB Horizontal Processing Facility (HPF) Flow Diagram. 3-2 11/14 11:00a

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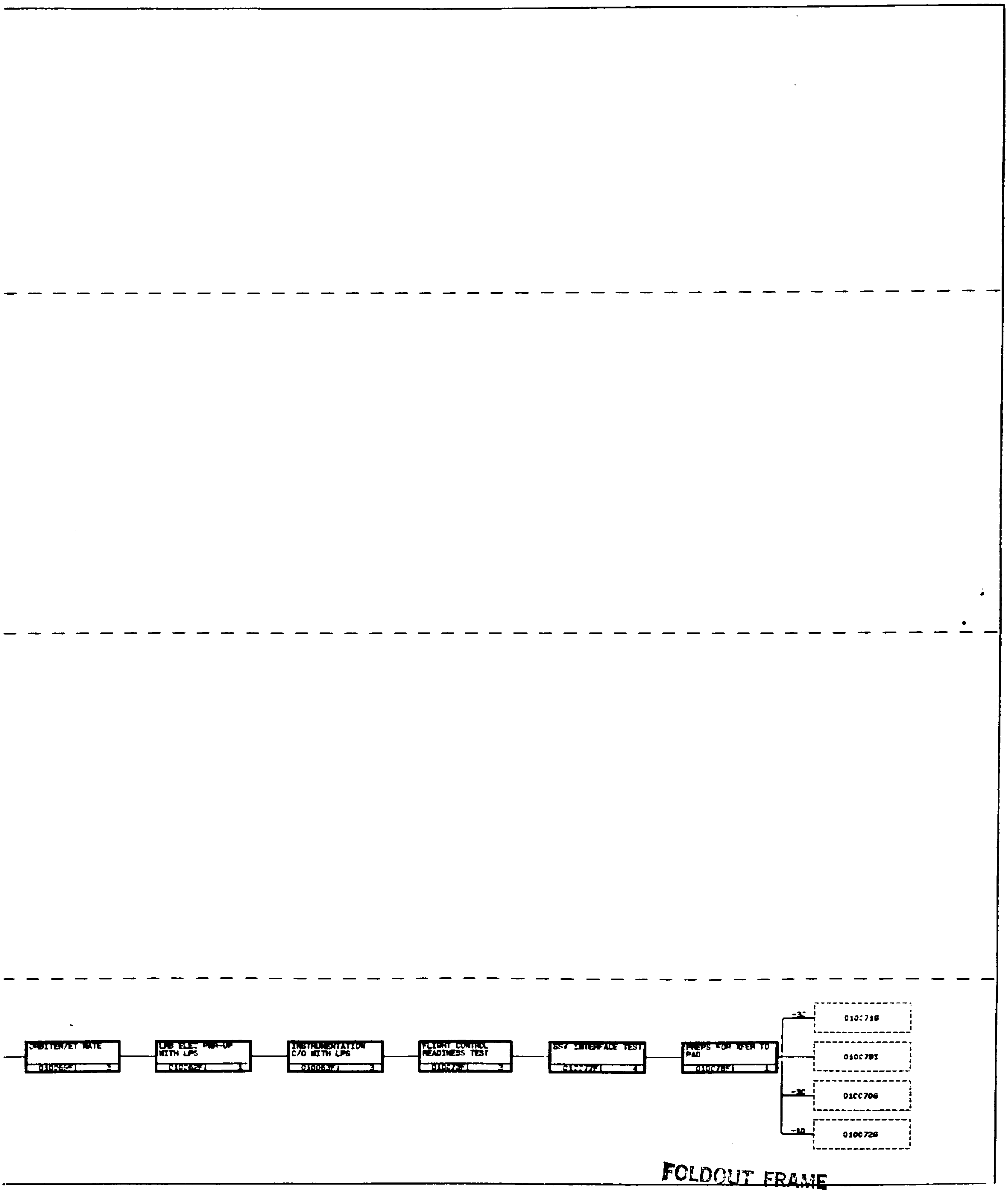
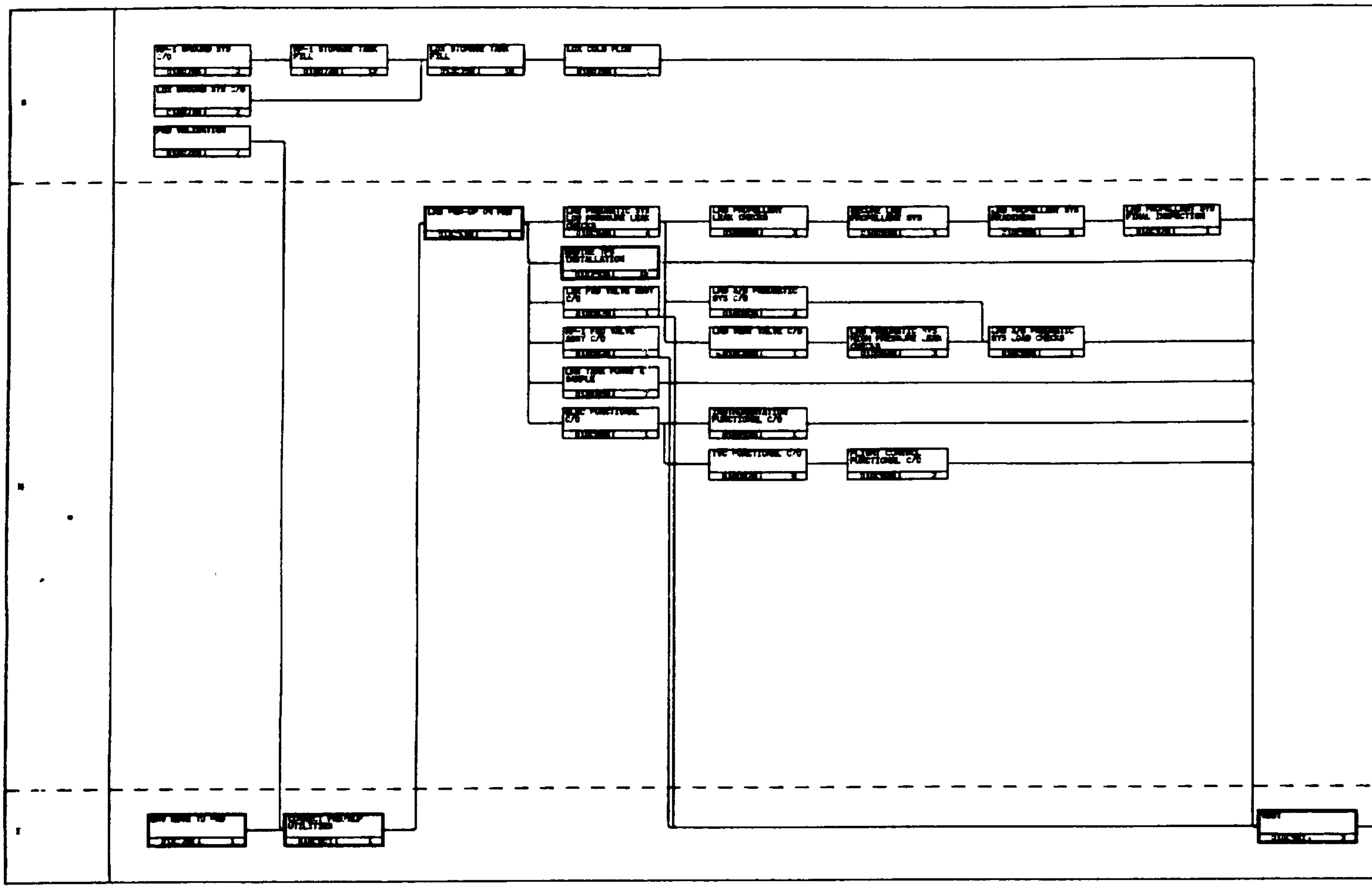


Figure 2.2-2. LRB MLP/VAB Processing Flow Diagram.



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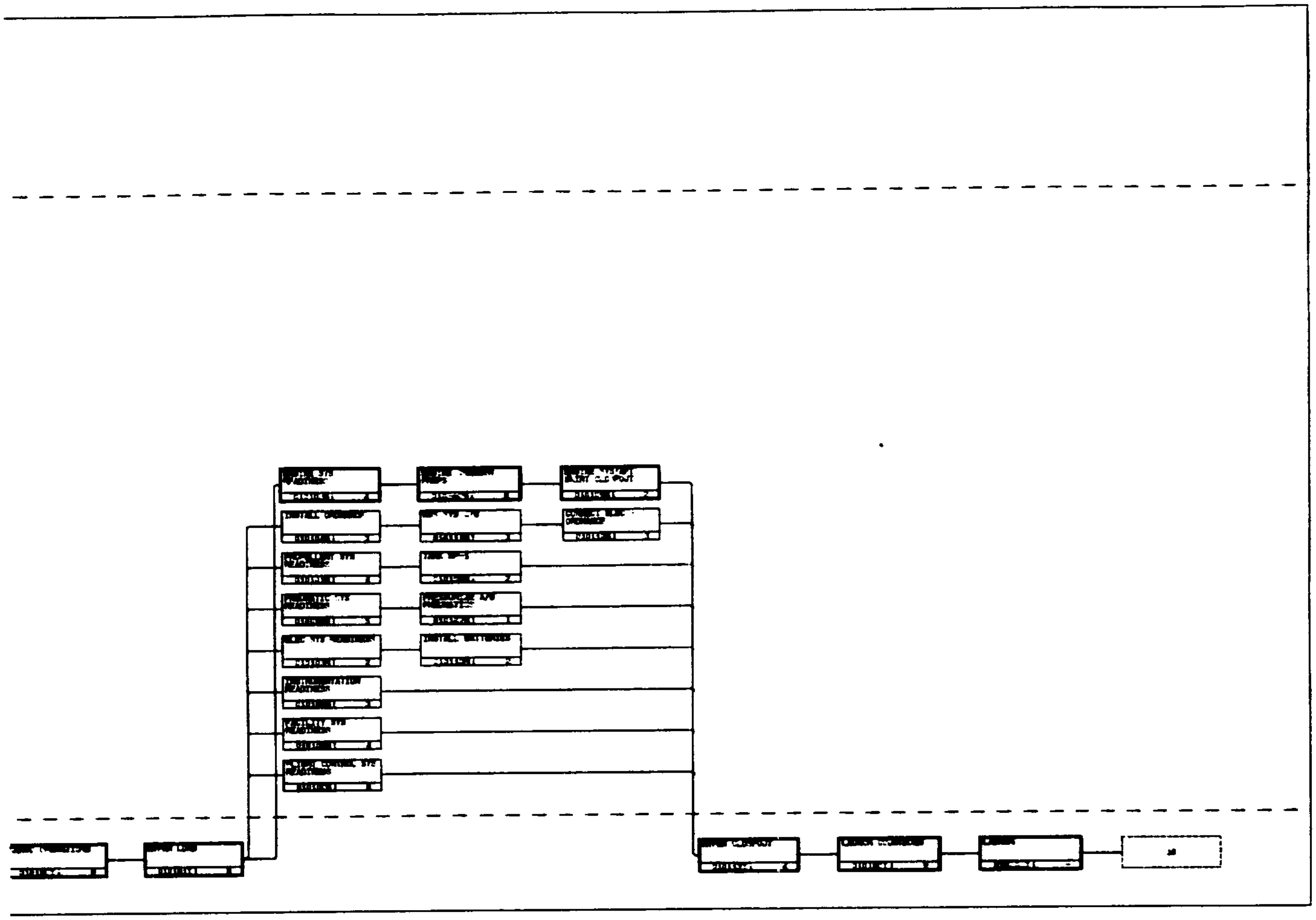
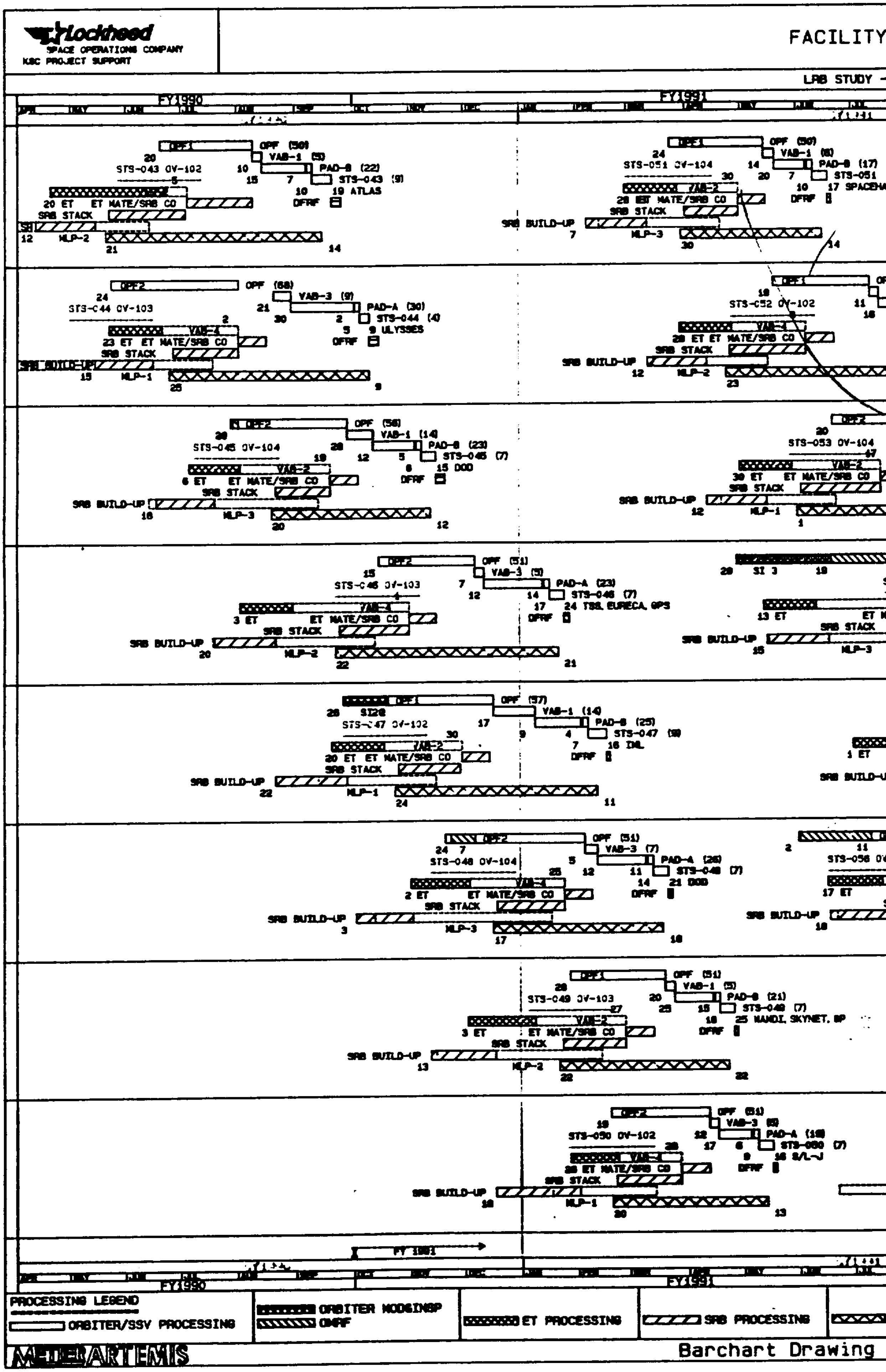


Figure 2.2-3. LRB Pad Processing Flow Diagram. 3-2 11/14 11:00a


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SPACE OPERATIONS COMPANY
KSC PROJECT SUPPORT
FACILITY
LRB STUDY -
FY1990
FY1991
STS-043 OV-102
PAD-B (22)
19 ATLAS
STS-044 OV-103
PAD-A (30)
9 ULYSSES
STS-045 OV-104
PAD-B (23)
15 DOD
STS-046 OV-103
PAD-A (23)
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STS-047 OV-102
PAD-B (25)
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16 S/L-J
STS-051 OV-104
PAD-B (17)
STS-052 OV-102
STS-053 OV-104
STS-056
ET MATE/SRB CO
SRB STACK
SRB BUILD-UP
MLP-1
MLP-2
MLP-3
OFRF
FY 1991
PROCESSING LEGEND
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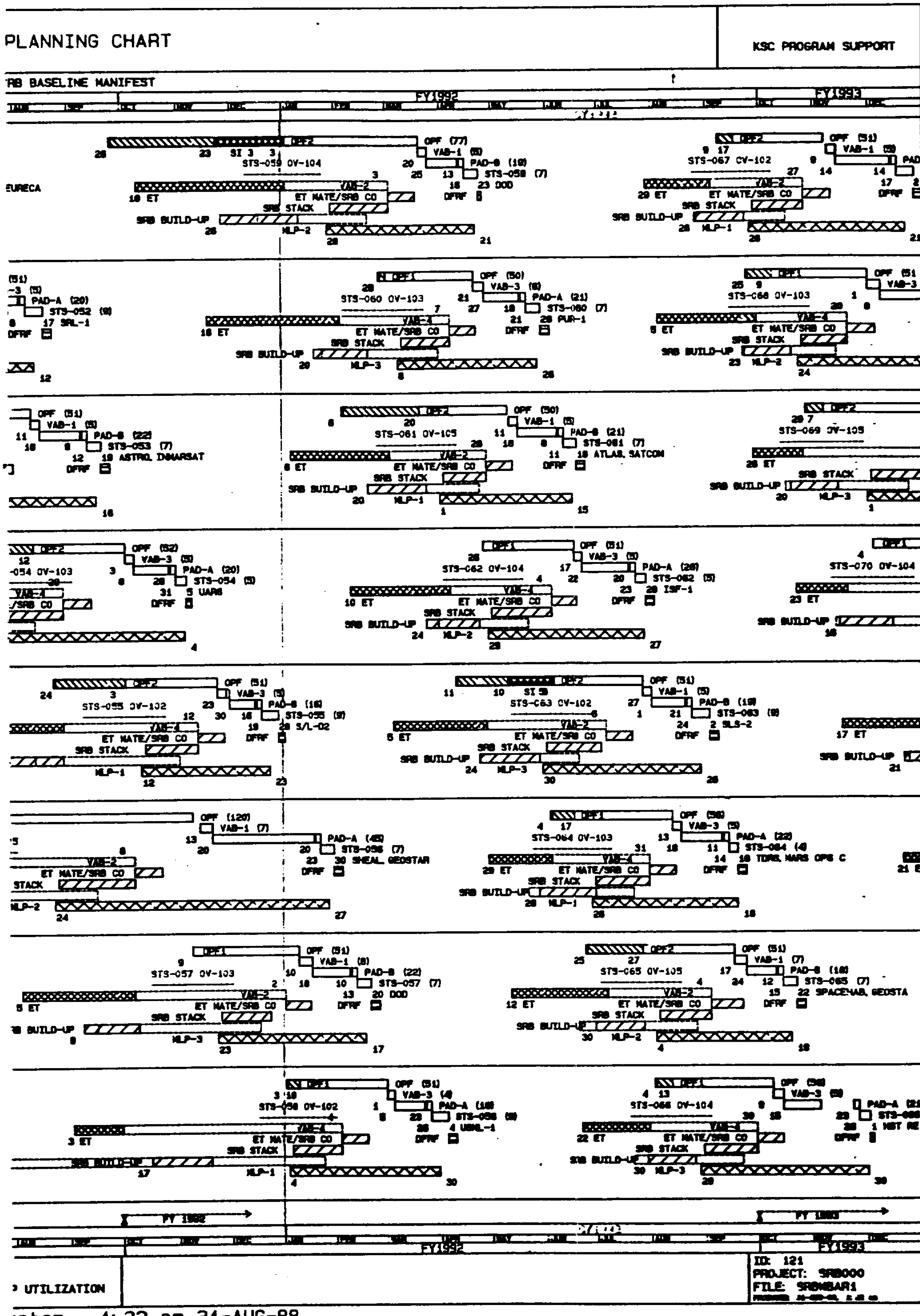
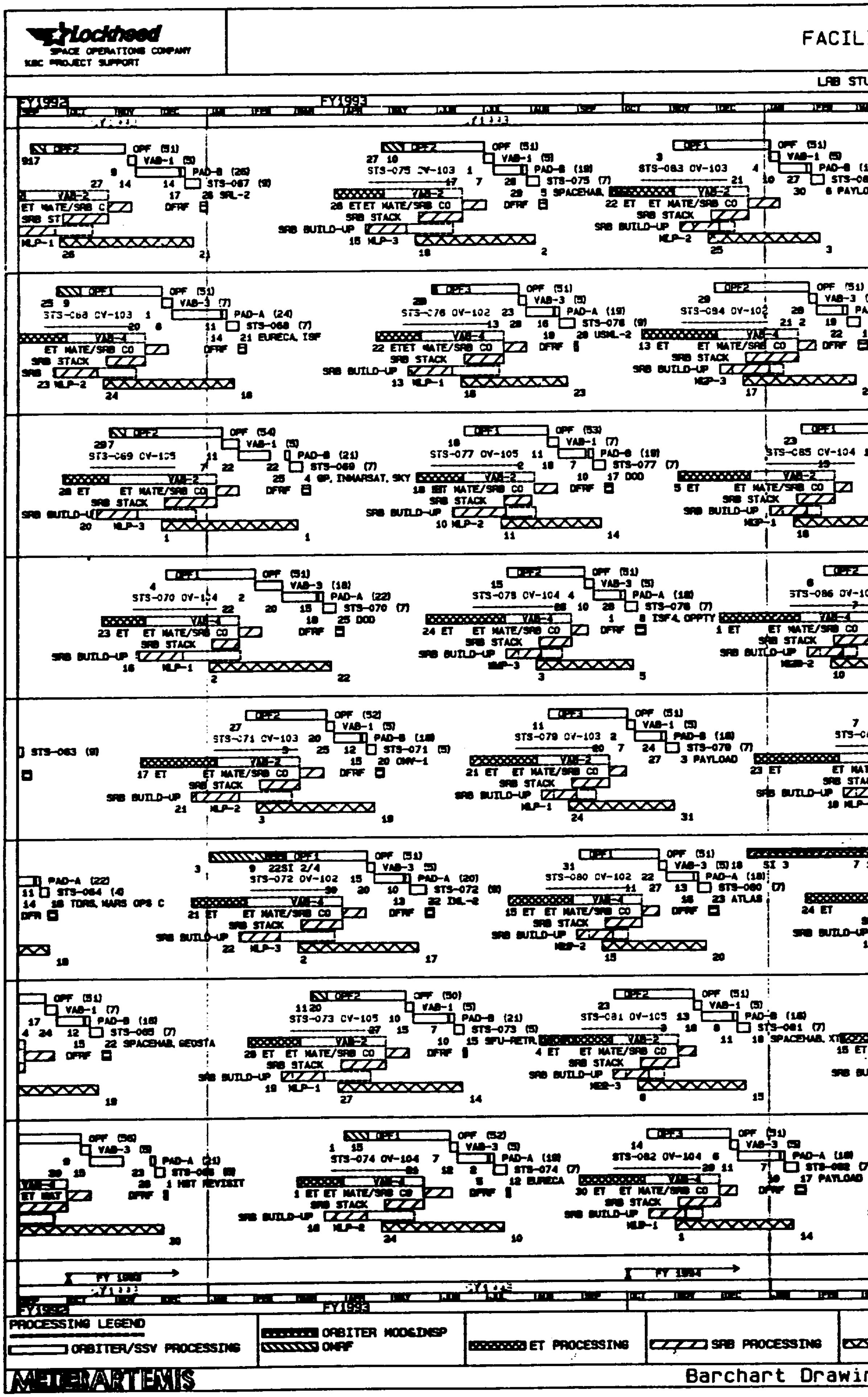


Figure 2.3.4-1 CY 1990 - 1992 Artemis STS Baseline

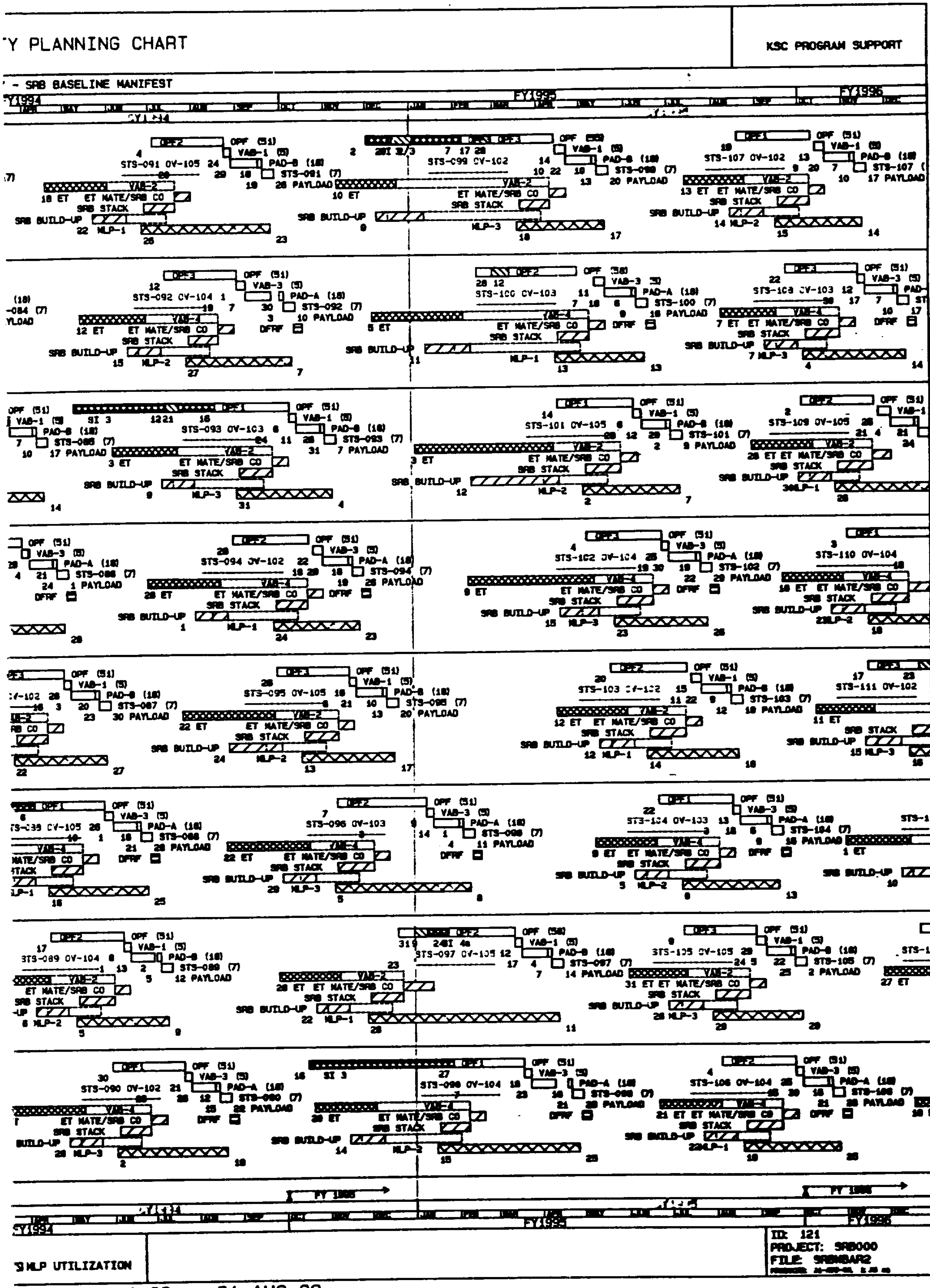
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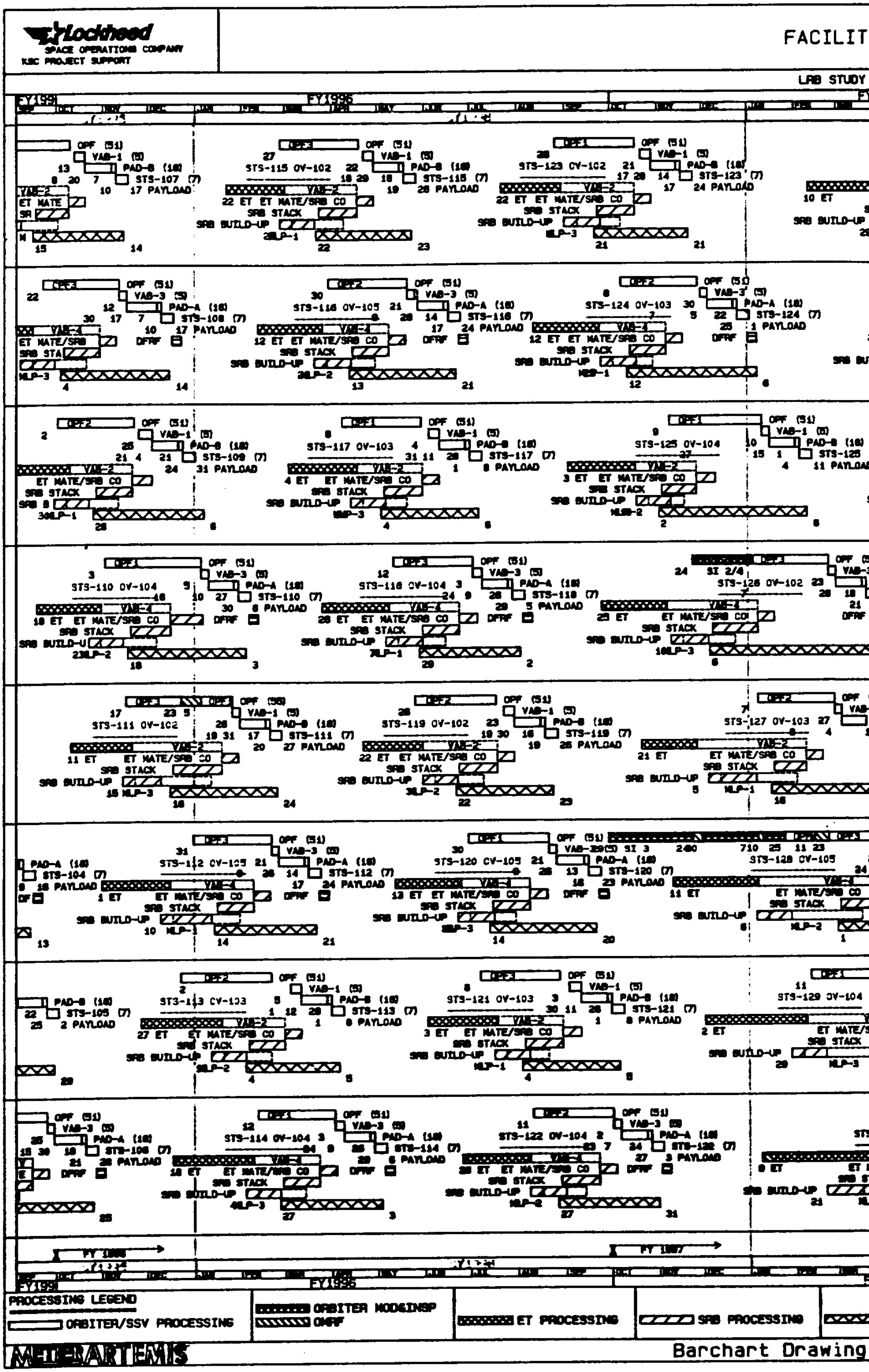
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Figure 2.3.4-2. CY 1993 - 1995 Artemis STS Baseline.

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PLANNING CHART

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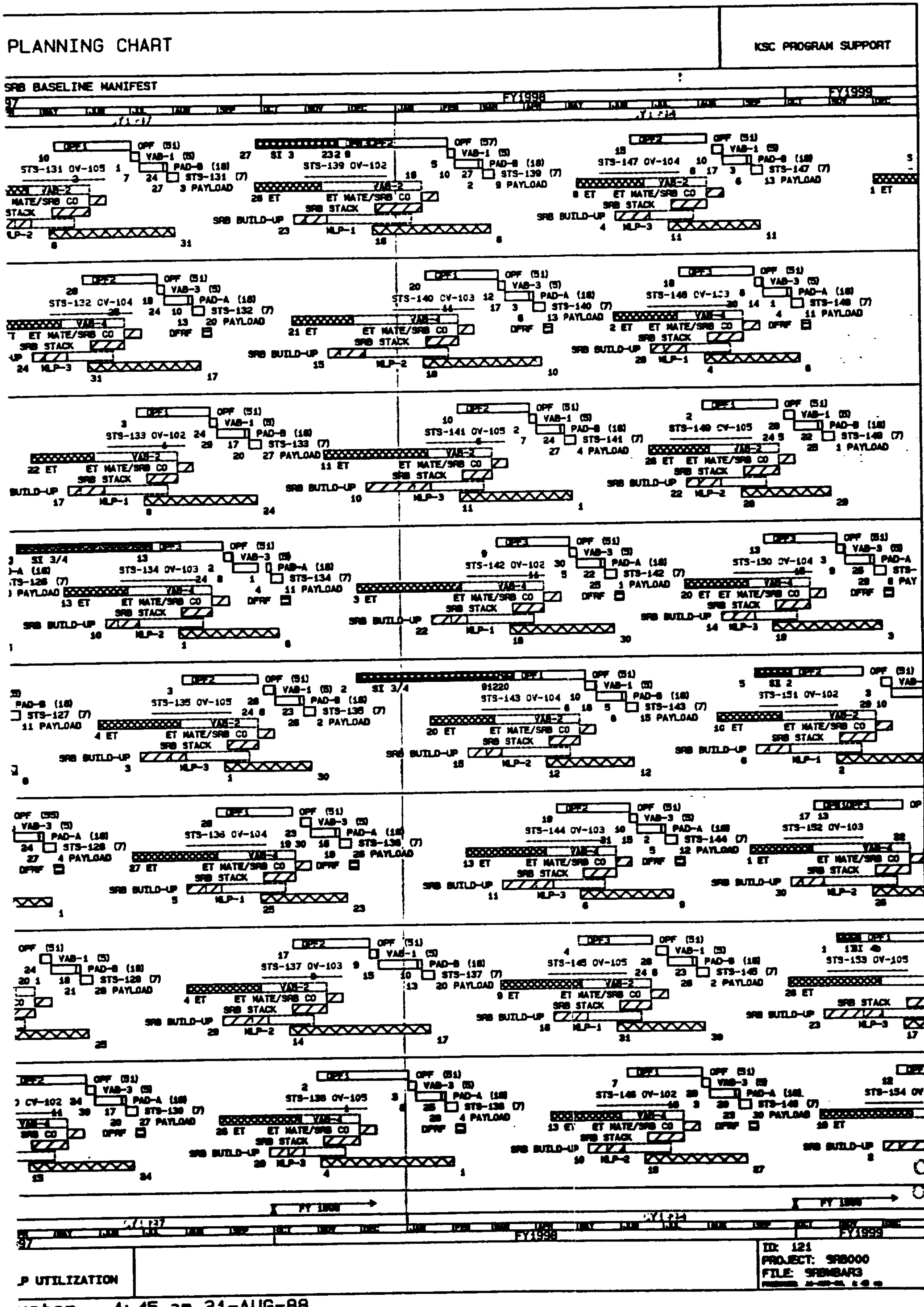
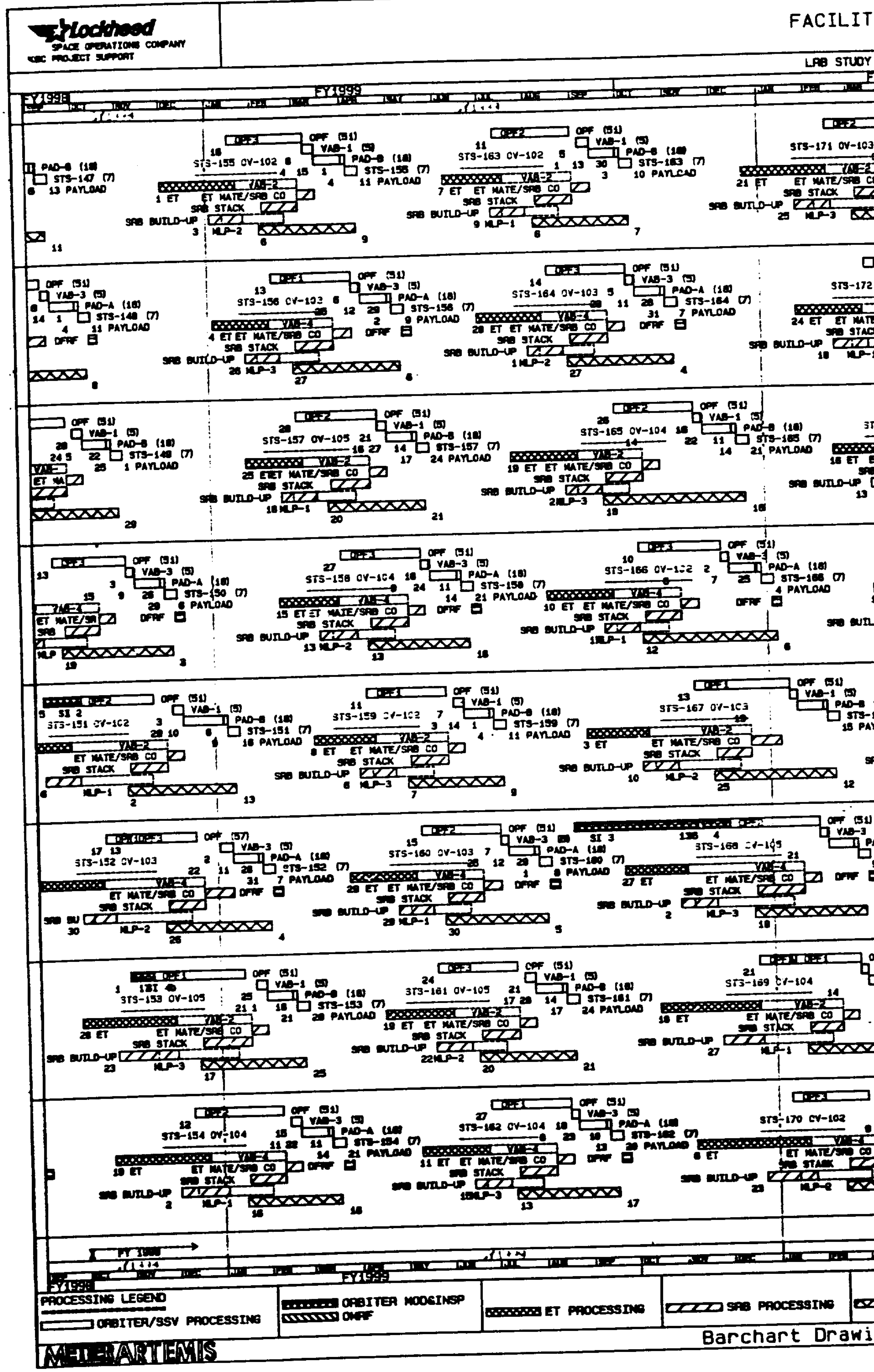


Figure 2.3.4-3. CY 1996 - 1998 Artemis STS Baseline.

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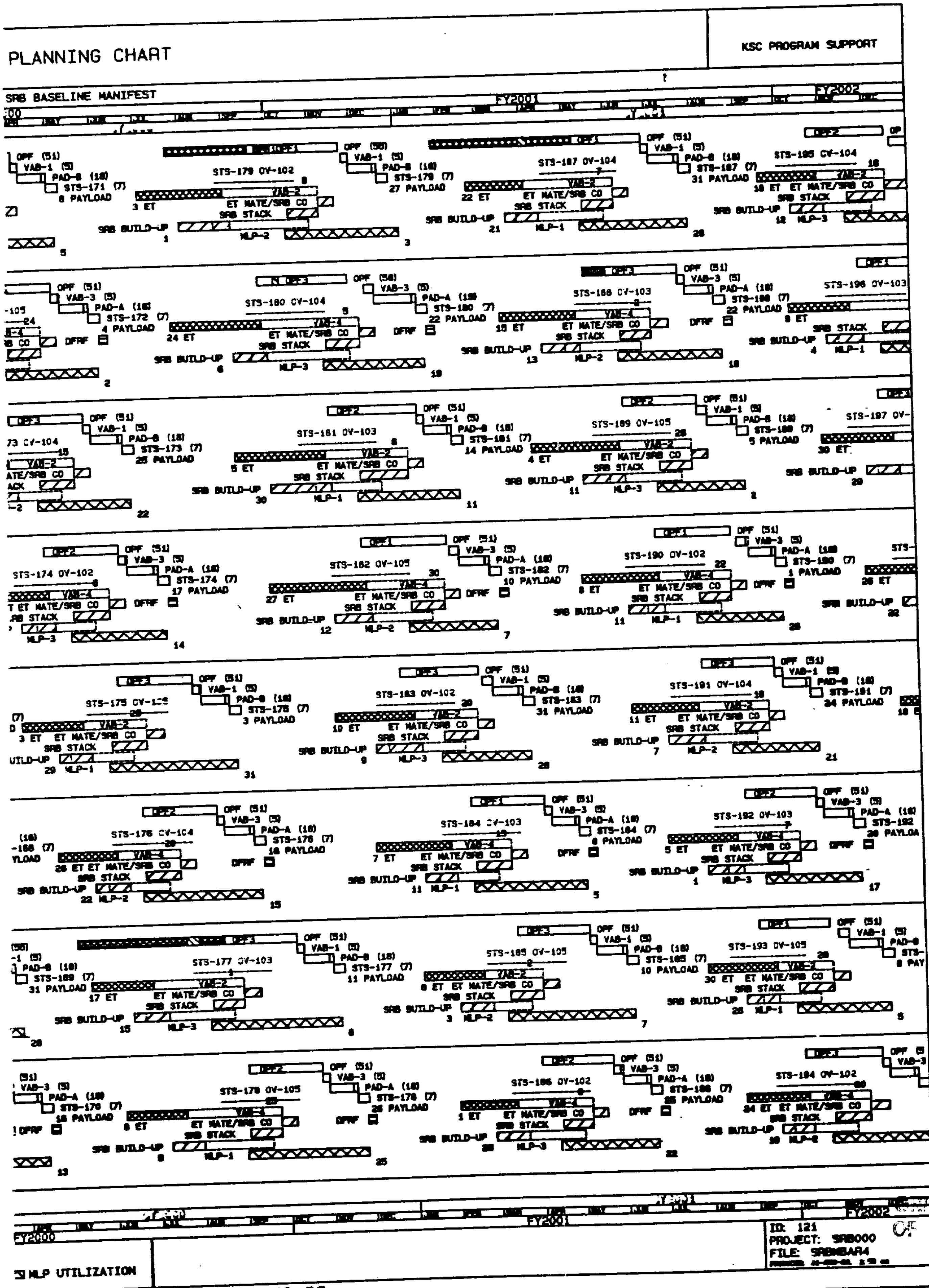


Figure 2.3.4-4. CY 1999 - 2001 Artemis STS Baseline.

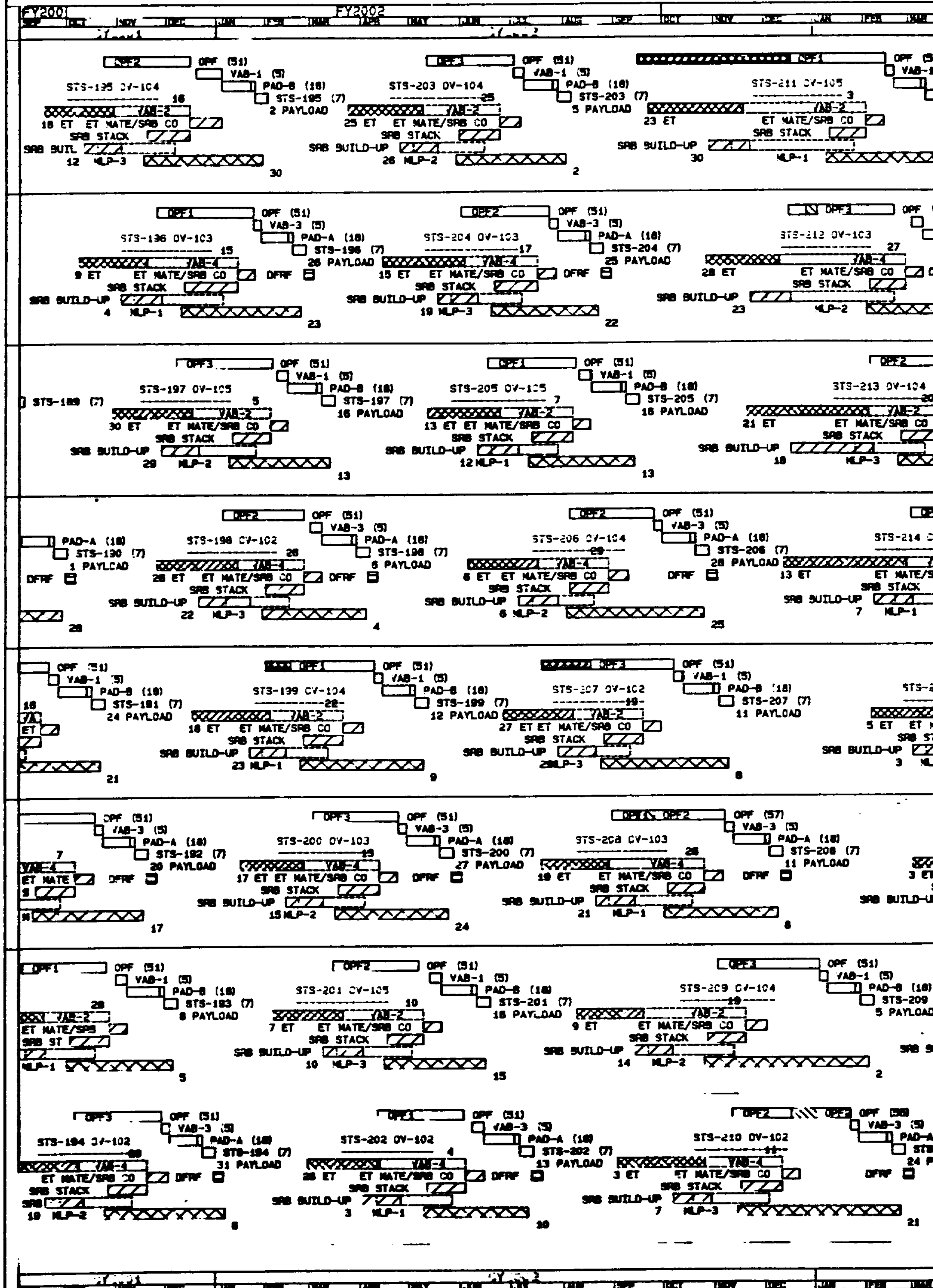
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Lockheed
SPACE OPERATIONS COMPANY
KSC PROJECT SUPPORT

FACILI

LRB STUD



PROCESSING LEGEND
ORBITER/SSV PROCESSING
ORBITER MODS&INSP
OMRF
ET PROCESSING
SRB PROCESSING

METERARTEMIS

Barchart Drawing

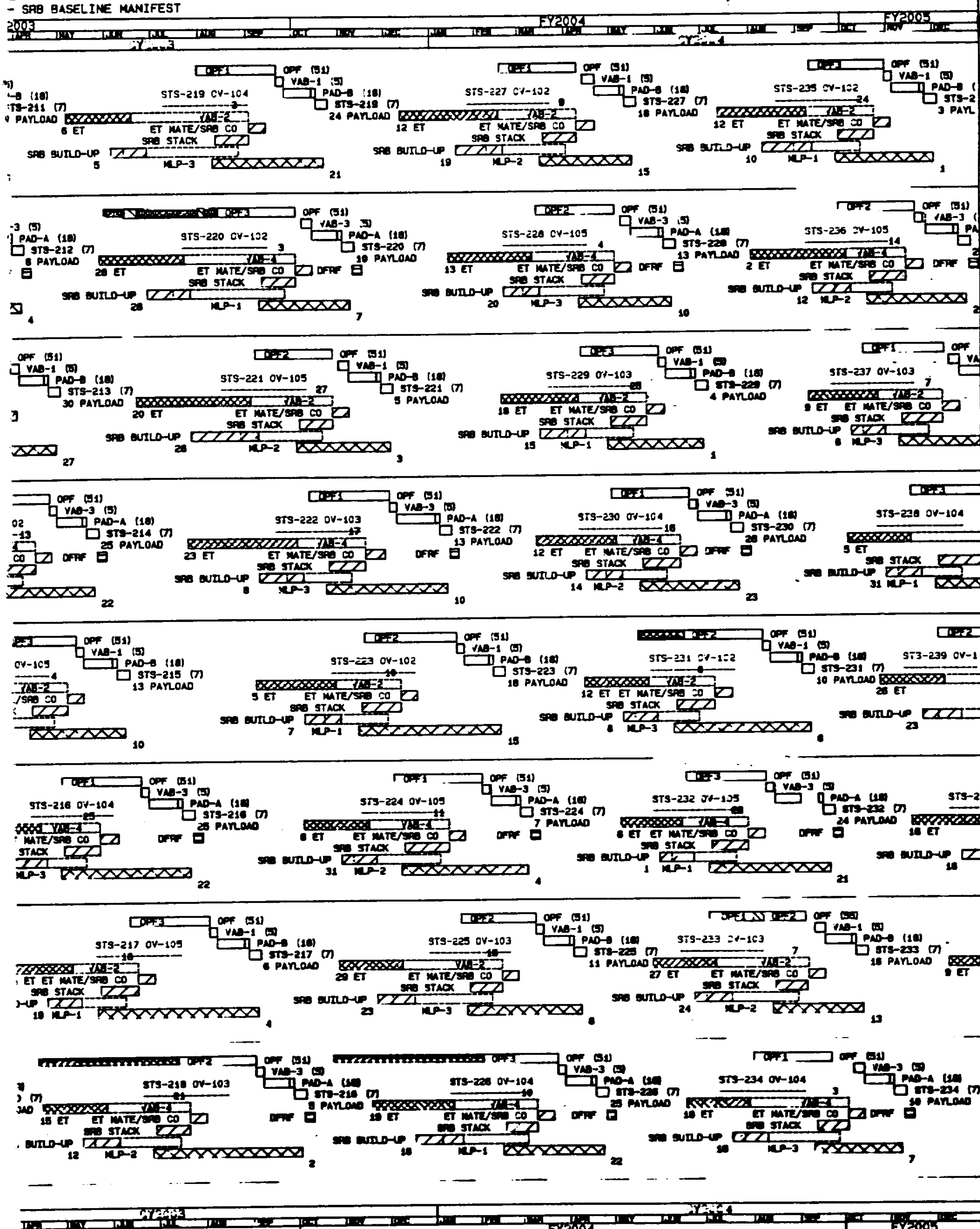
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Y PLANNING CHART

KSC PROGRAM SUPPORT

- SRB BASELINE MANIFEST



MLP UTILIZATION

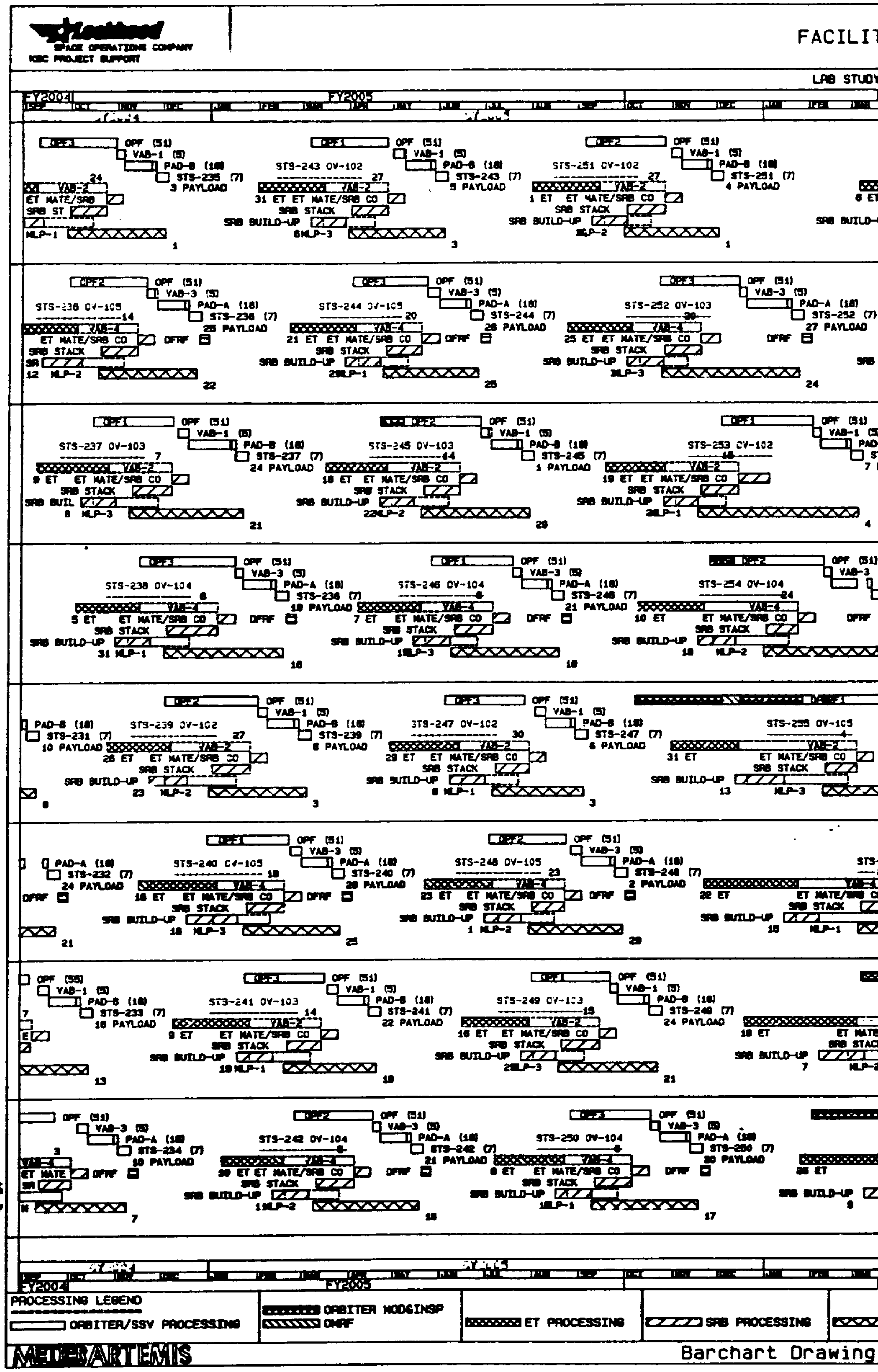
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FILE: SRBBARS

System 2: 10 am 31-AUG-88

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Figure 2.3.4-5. CY 2002 - 2004 Artemis STS Baseline

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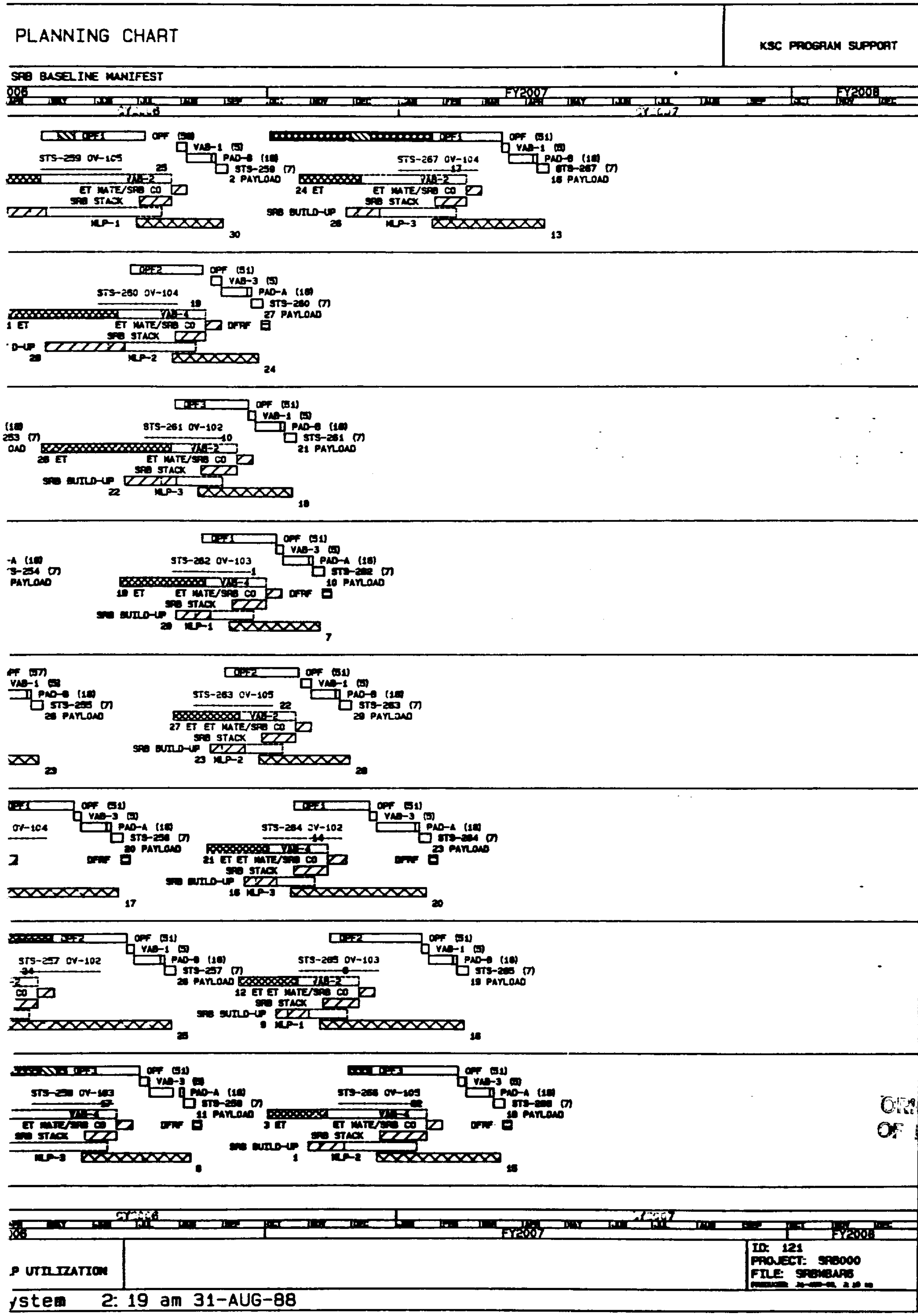
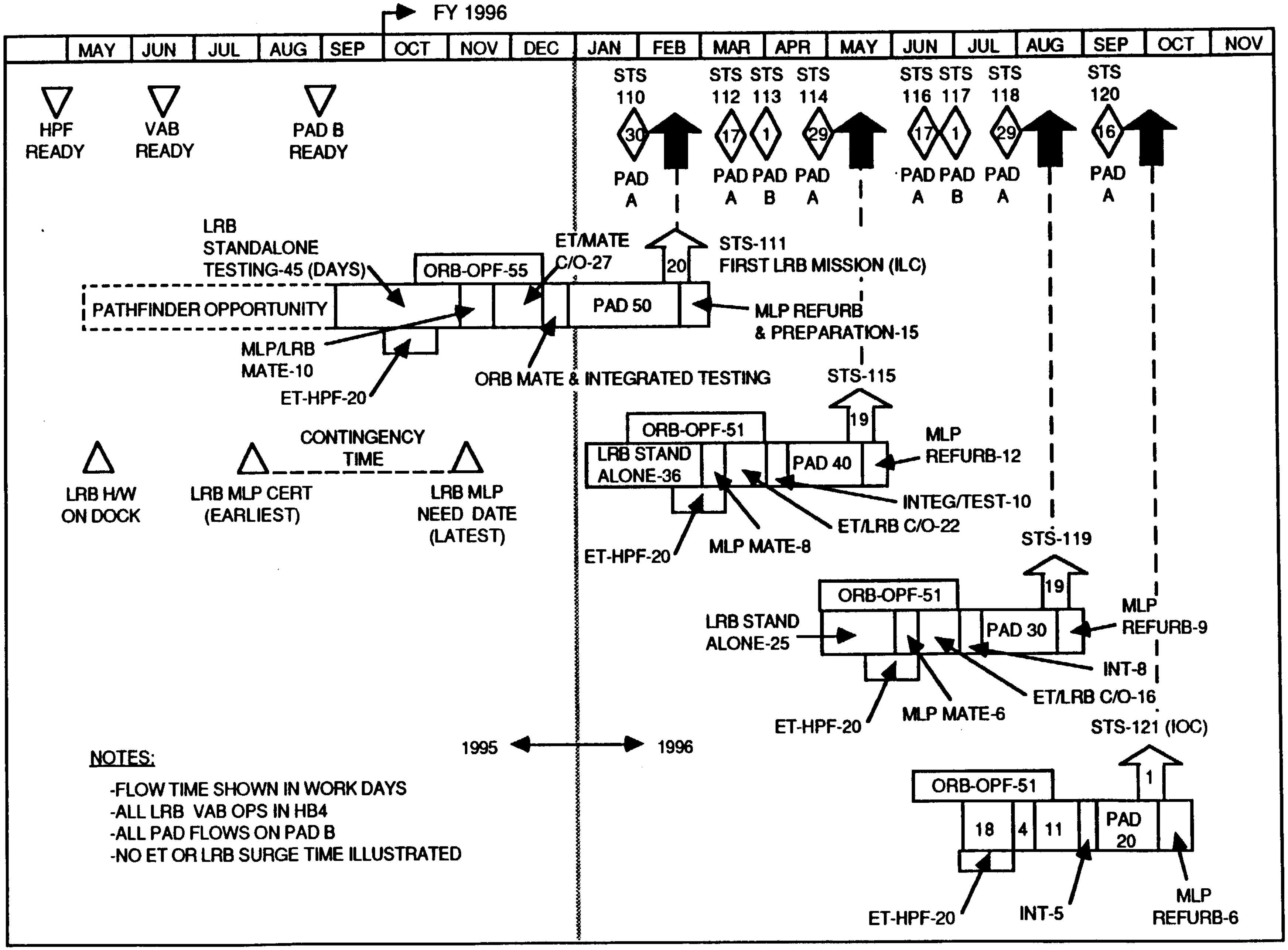


Figure 2.3.4-6. Cy 2005 - 2007 Artemis STS Baseline.



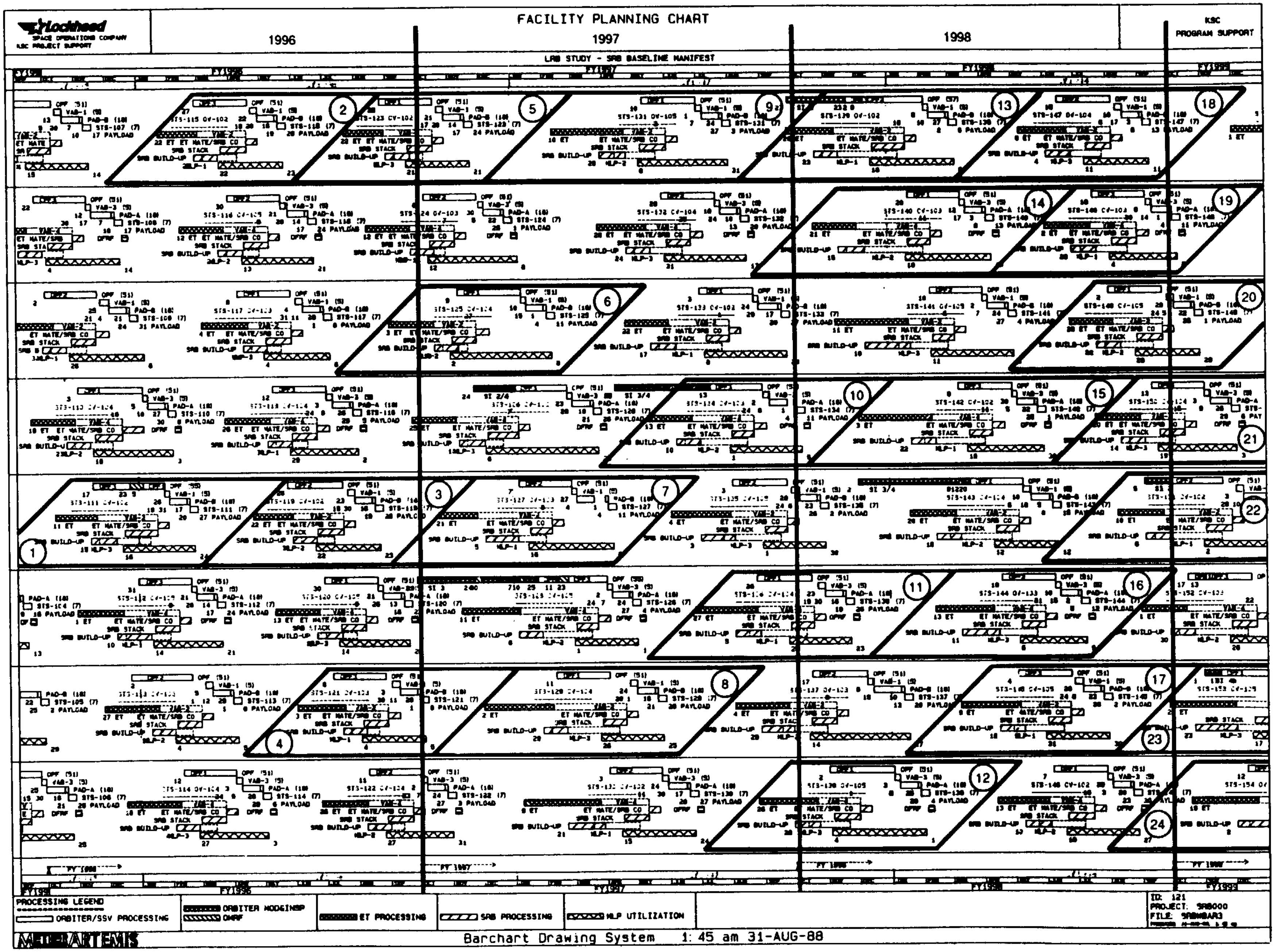
NOTES:

- -FLOW TIME SHOWN IN WORK DAYS
- -ALL LRB VAB OPS IN HB4
- -ALL PAD FLOWS ON PAD B
- -NO ET OR LRB SURGE TIME ILLUSTRATED

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Figure 2.5-1. LRB Processing/Launch Transition To I.O.C.

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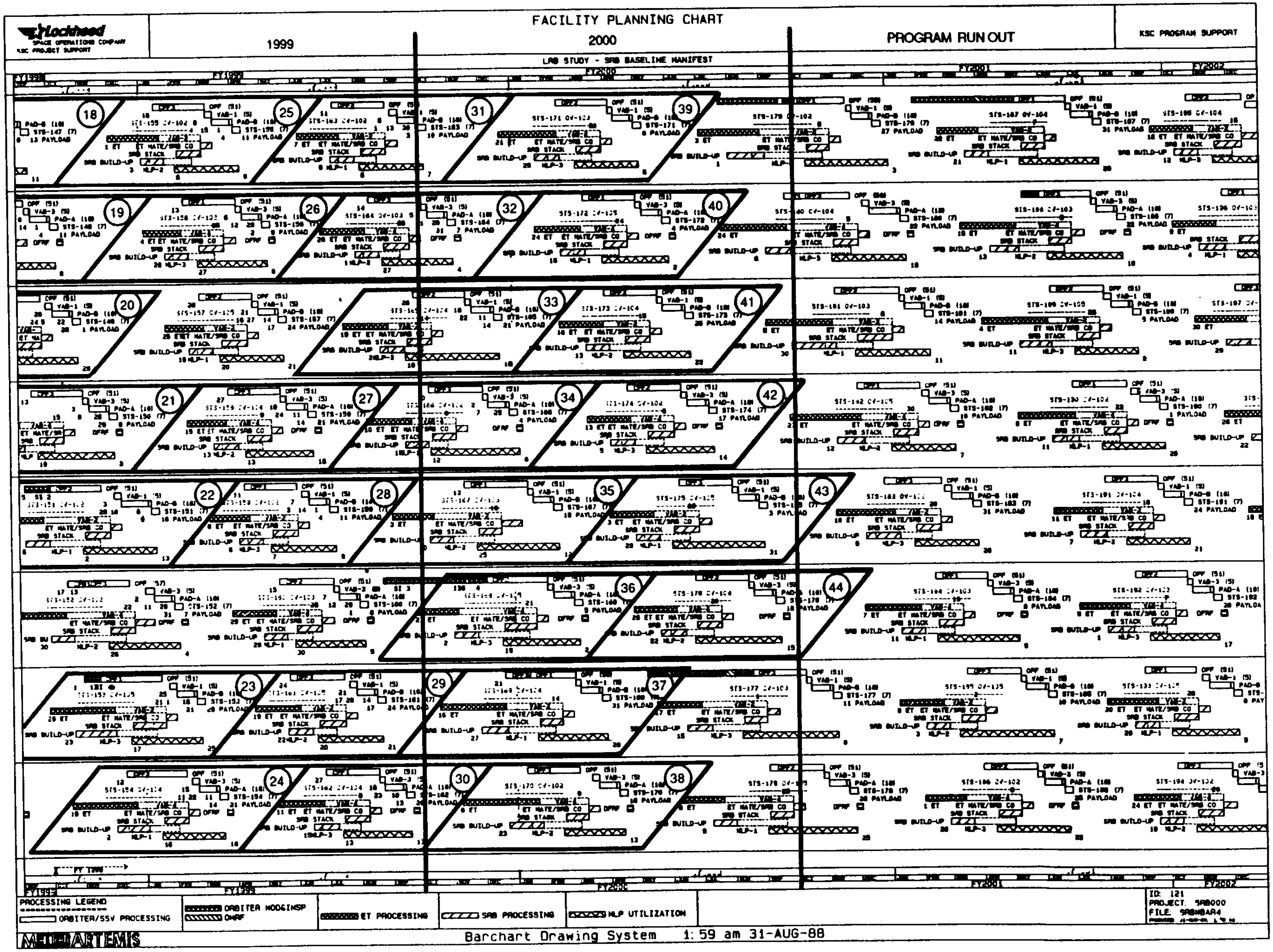


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Figure 2.6-1. LRB Transition Missions, Page 1.

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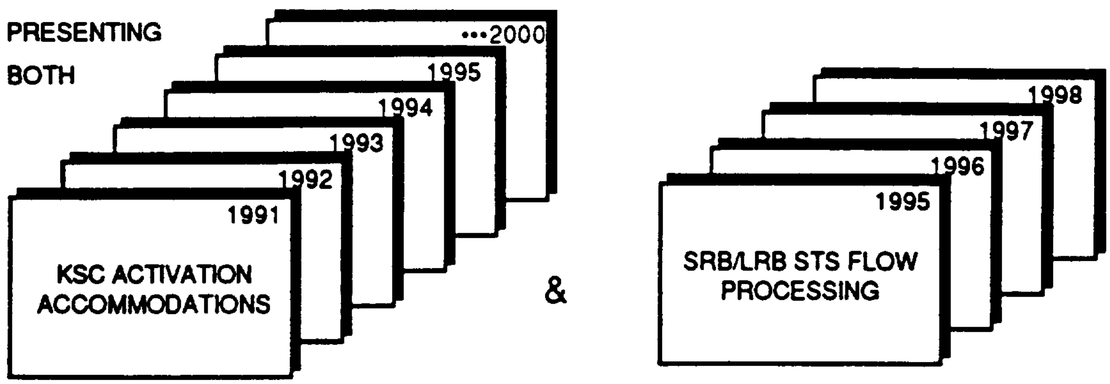


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Figure 2.6-2. LRB Transition Missions, Page 2.

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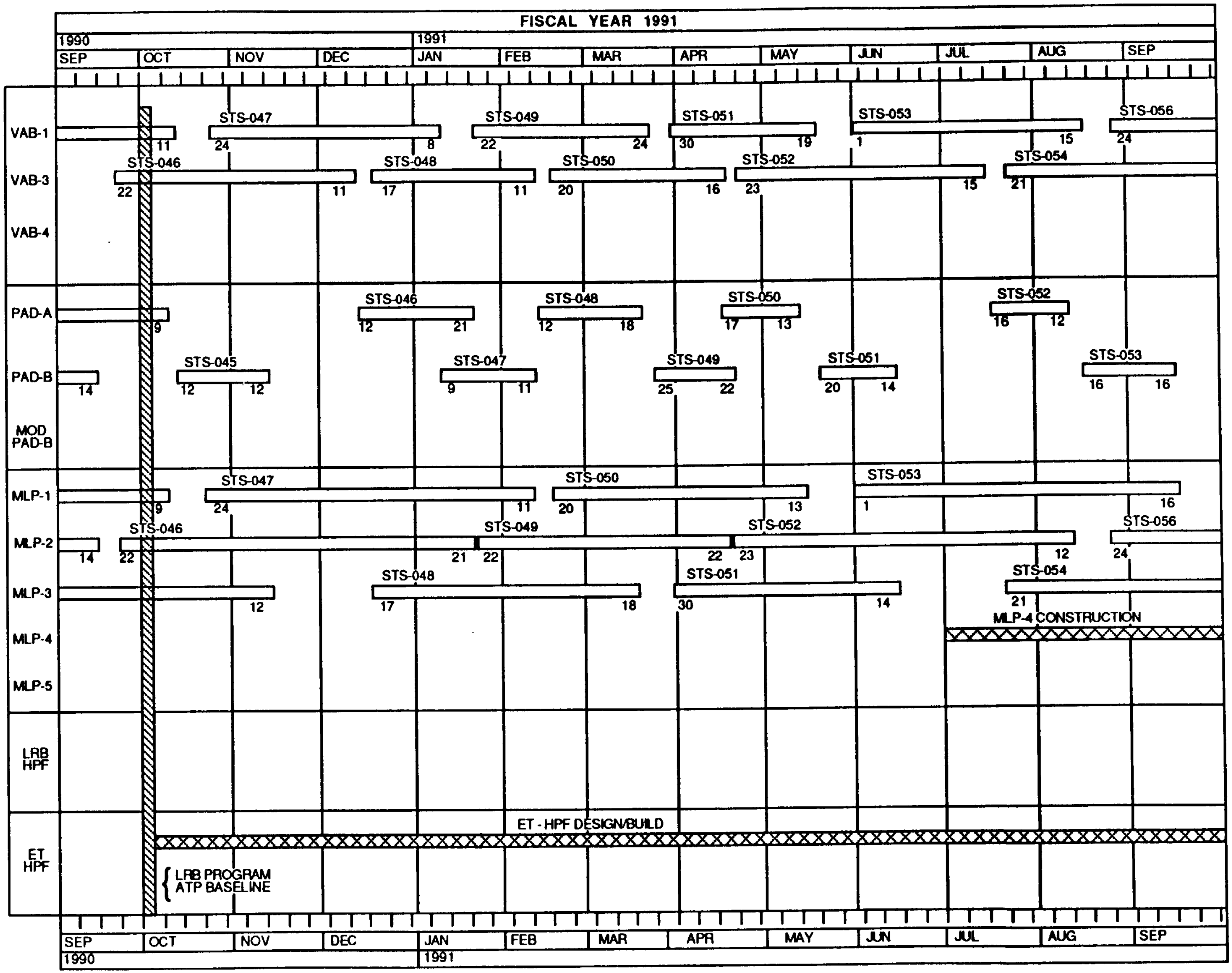
FY1991-2000
KSC SRB/LRB PROCESSING FACILITY UTILIZATION
(FIGURES 2.6-4 THRU 2.6-13)



INTERPRETIVE REMARKS

- ACTIVATION/CONSTRUCTION BARS INCLUDE THE SCHEDULE FLEXIBILITY (ie. FLOAT TIME) ALLOWANCE FOR EACH ACTIVITY.
- ARROWS INDICATE FACILITY PROCESSING ACTIVITIES DISPLACED TO ALTERNATE FACILITIES.
- 'X's INDICATE FLOW PROCESSING REQUIREMENTS PERFORMED ELSEWHERE DUE TO THE CHANGE FROM SRB TO LRB.
- LRB FLIGHT PROCESSING FACILITY BARS FOR STS-111 THROUGH STS-147 WERE ADJUSTED FOR LRB (ie. SHORTER FLOW TIME, EXCEPT AT PAD)
- ALL MISSION PROCESSING FLOWS WERE BASED ON KEEPING THE LAUNCH DATE FIXED (LRB PROCESSING ACTIVITIES WERE "BACKED OFF" TO MAINTAIN THE PROJECTED LAUNCH DATE).
- PAD TIME BARS INCLUDE A 4 DAY REFURB AFTER LAUNCH.
- MLP TIME BARS INCLUDE 4 DAY REFURB AFTER LAUNCH AND 2 DAY HDP VERIFICATION PRIOR TO THE START OF VAB INTEGRATION.

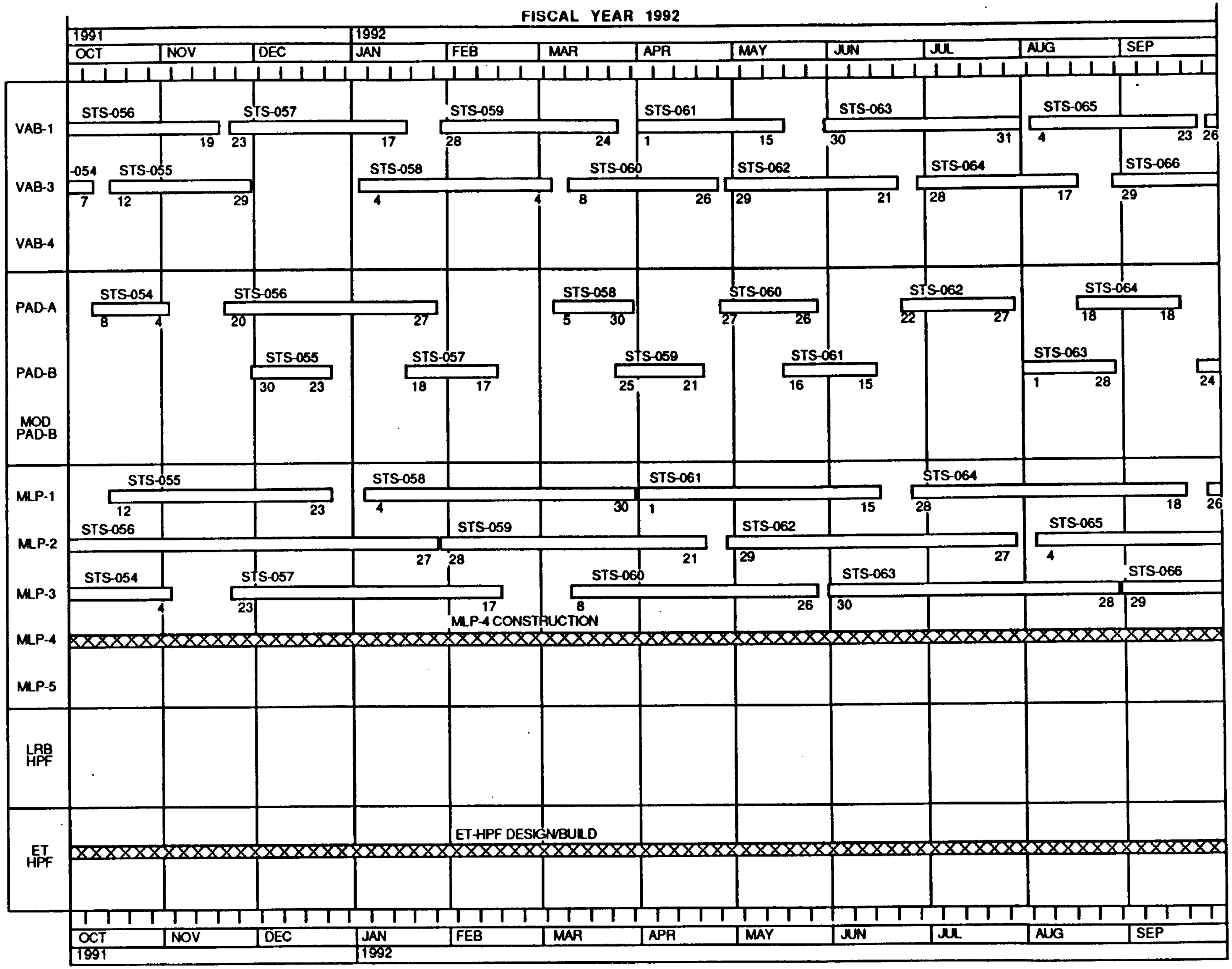
Figure 2.6-3. Overview of Facility Utilization Projections.



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Figure 2.6-4. FY1991 KSC SRB/LRB Processing Facility Utilization.

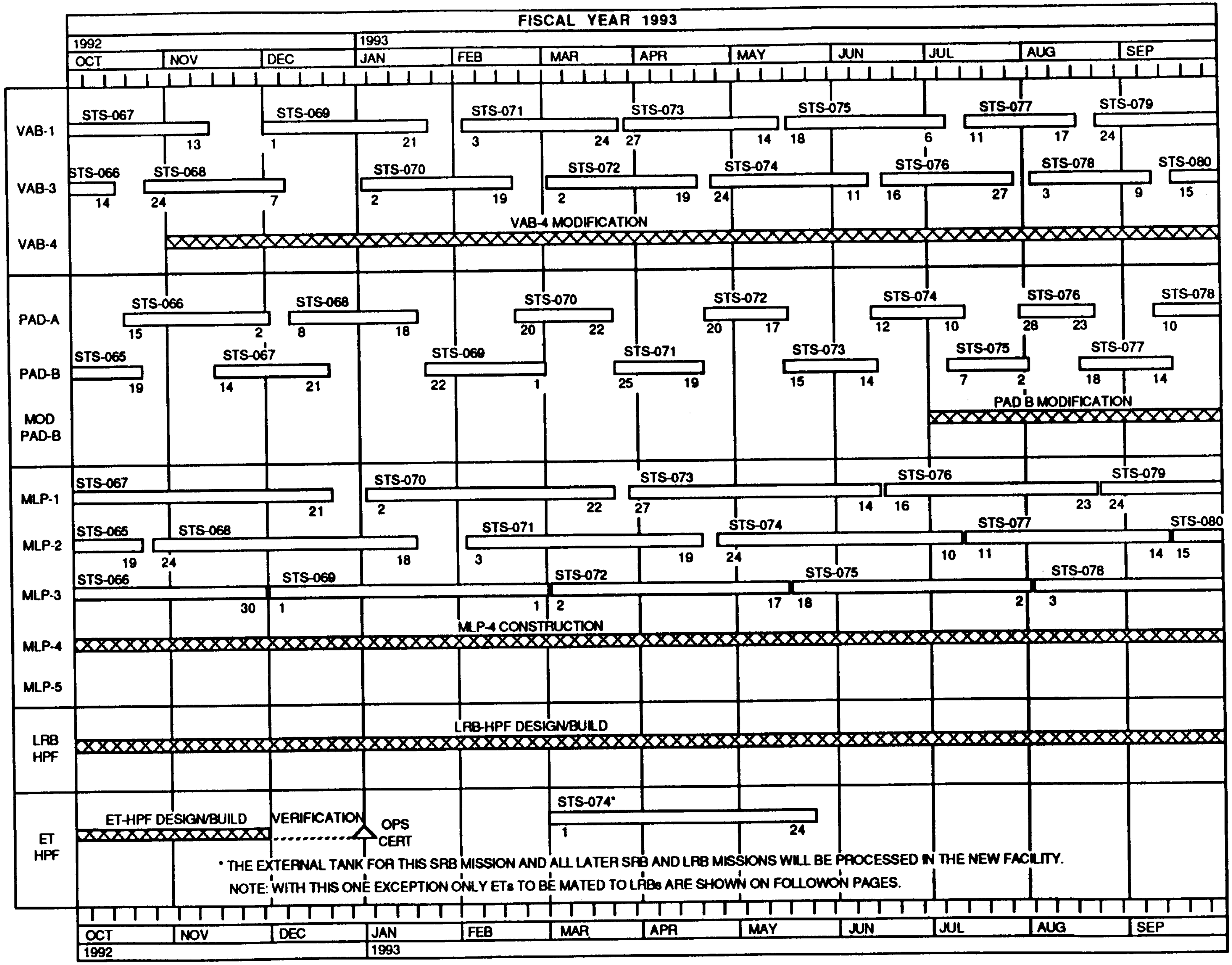
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Figure 2.6-5. FY1992 KSC SRB/LRB Processing Facility Utilization.

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Figure 2.6-6. FY1993 KSC SRB/LRB Processing Facility Utilization.

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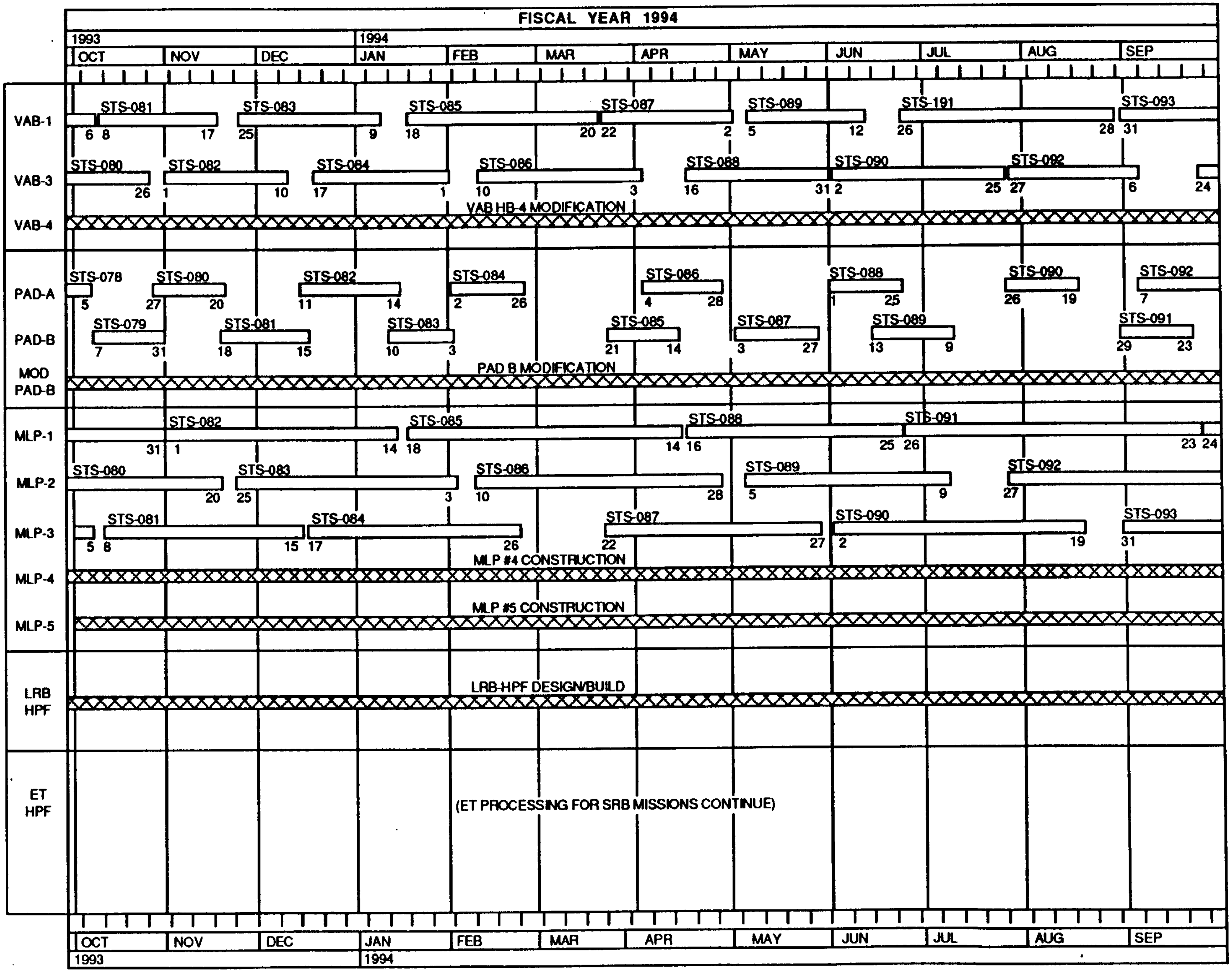
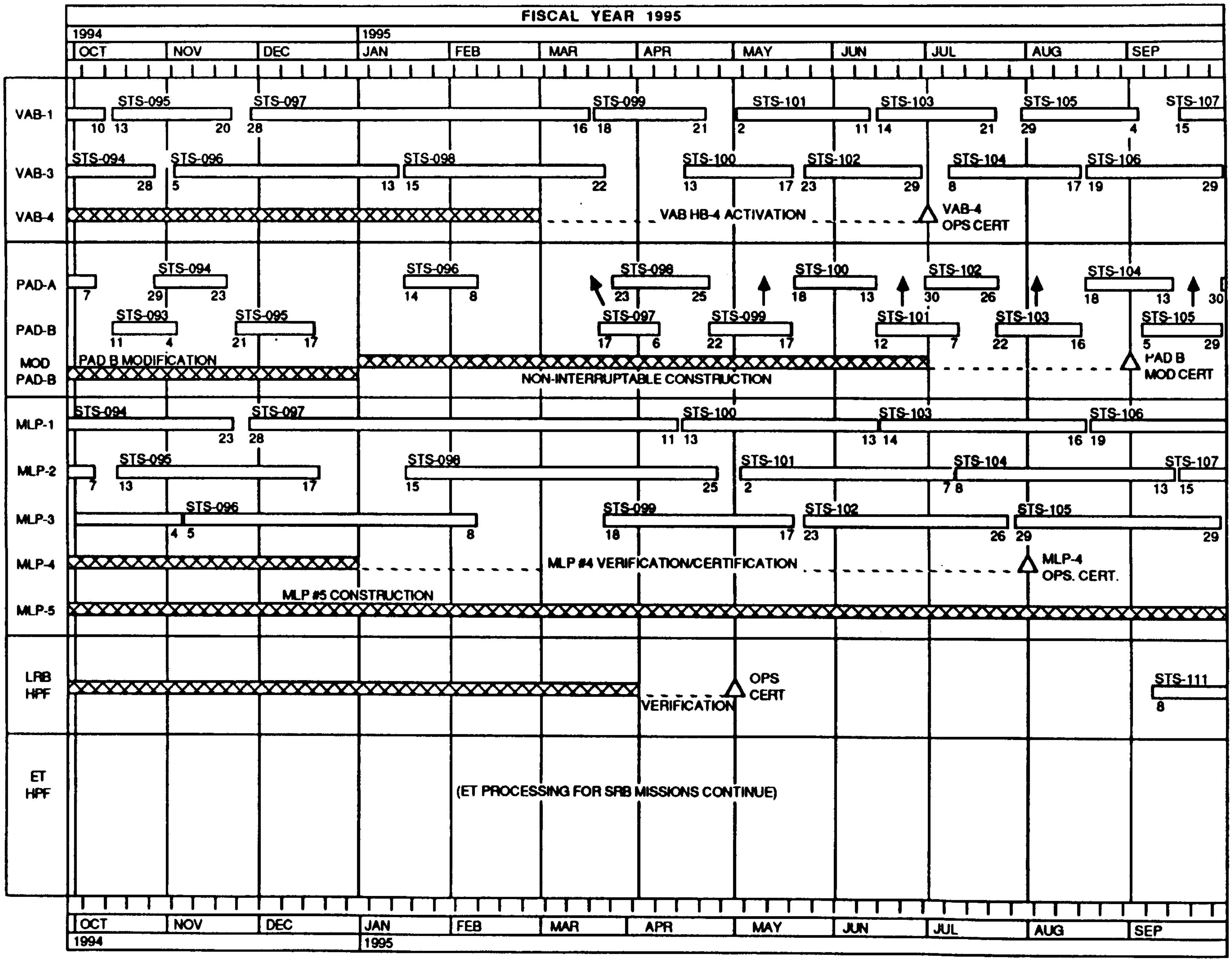


Figure 2.6-7. FY1994 KSC SRB/LRB Processing Facility Utilization.

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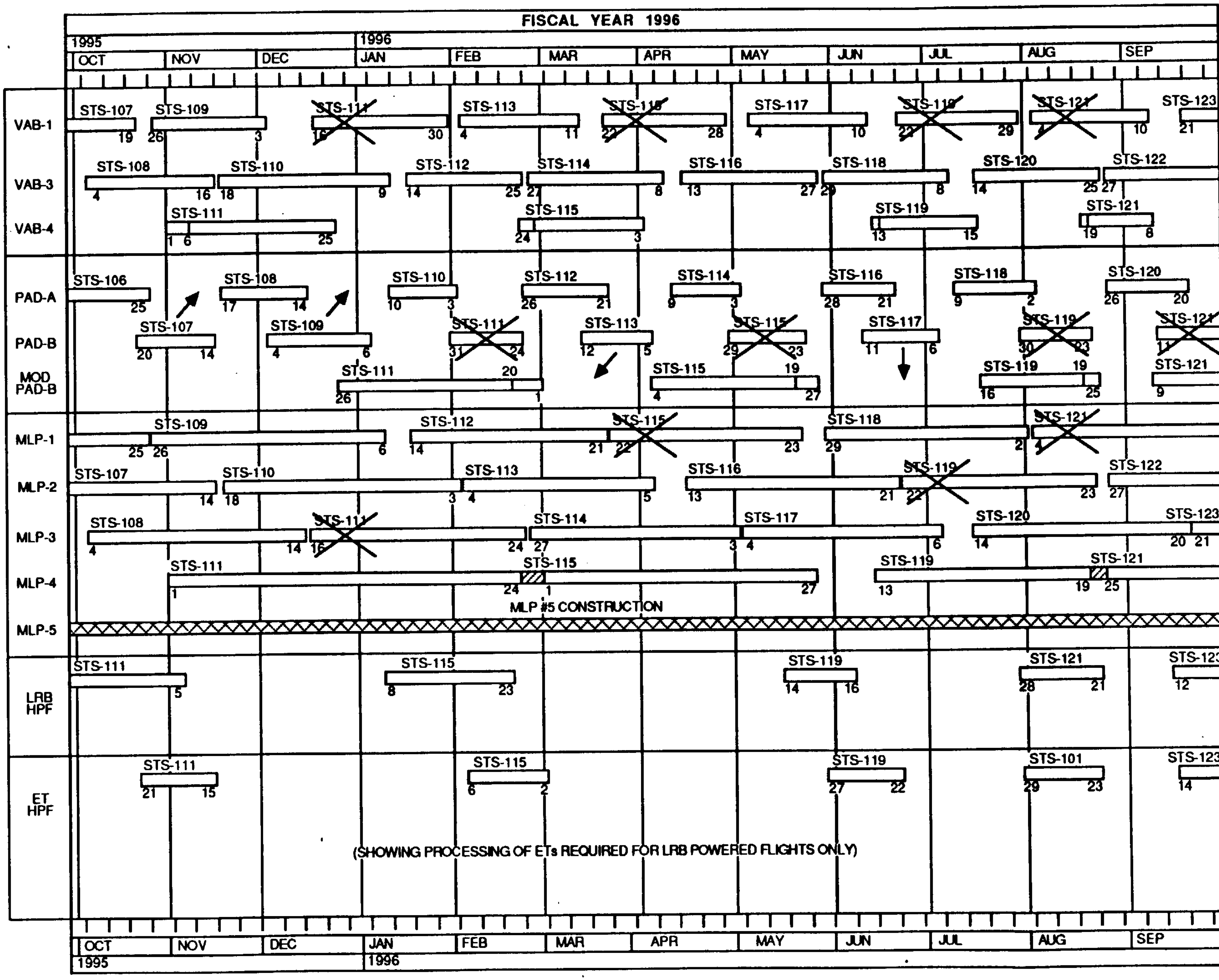
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Figure 2.6-8. FY1995 KSC SRB/LRB Processing Facility Utilization.

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Figure 2.6-9. FY1996 KSC SRB/LRB Processing Facility Utilization.

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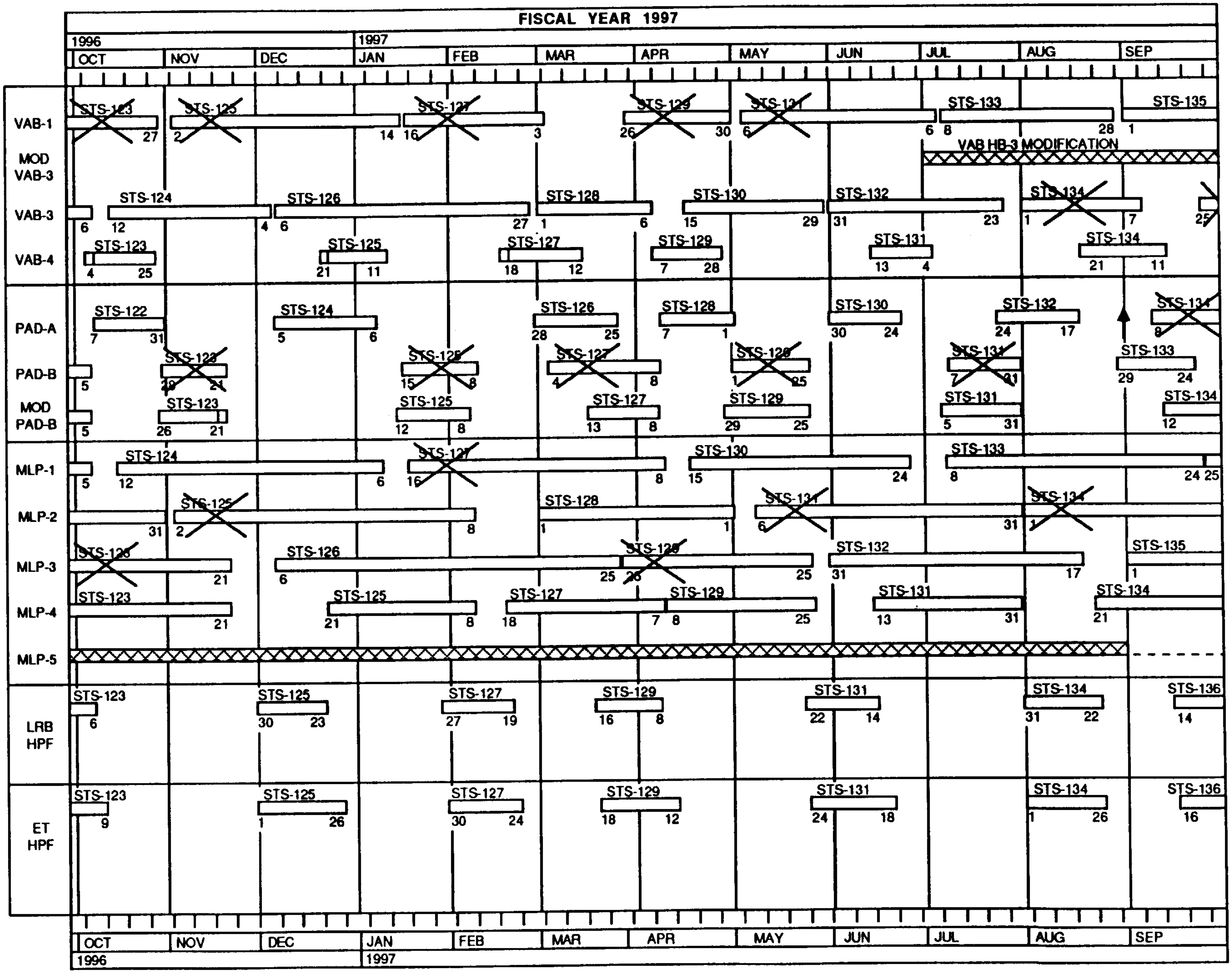
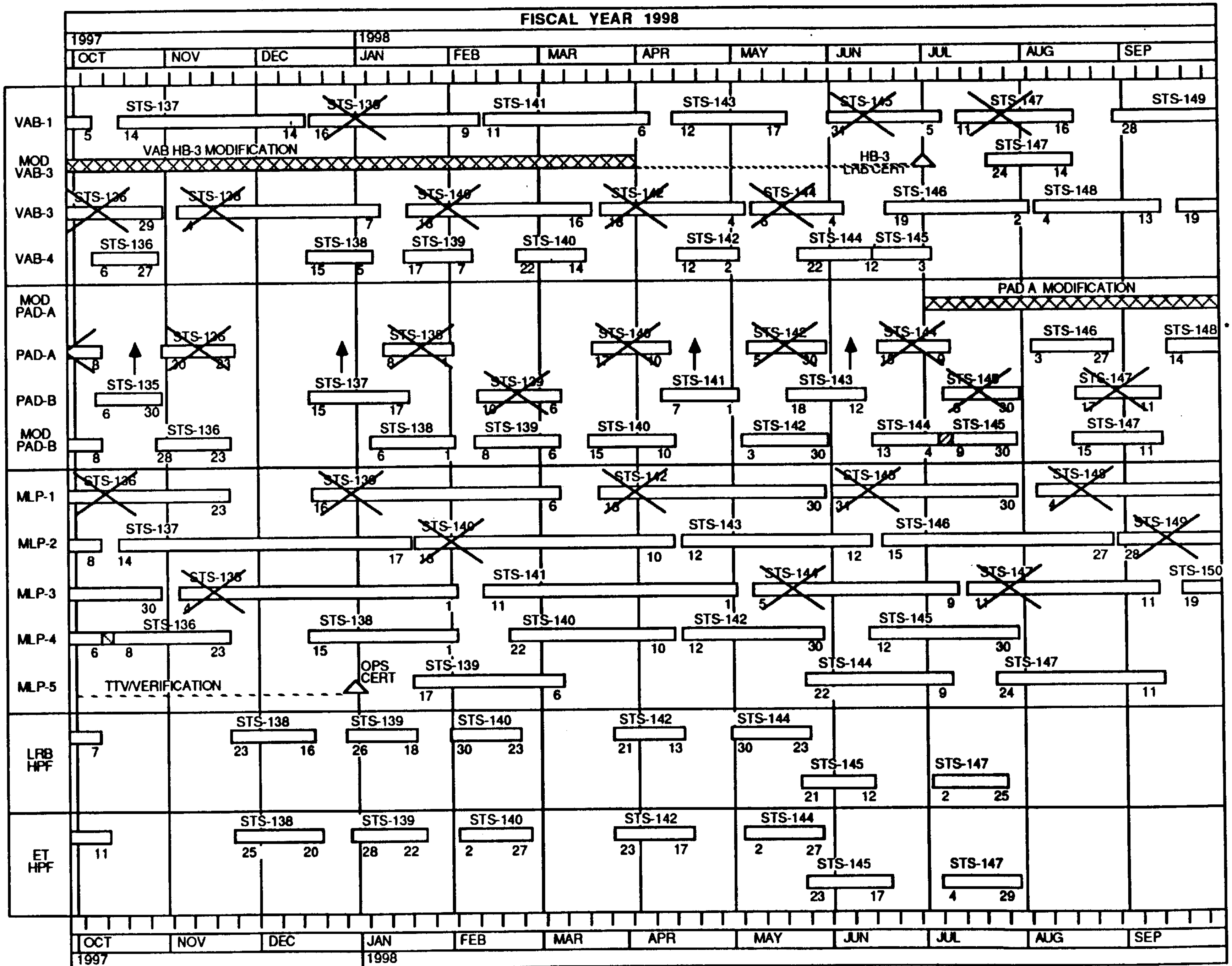


Figure 2.6-10. FY1997 KSC SRB/LRB Processing Facility Utilization.

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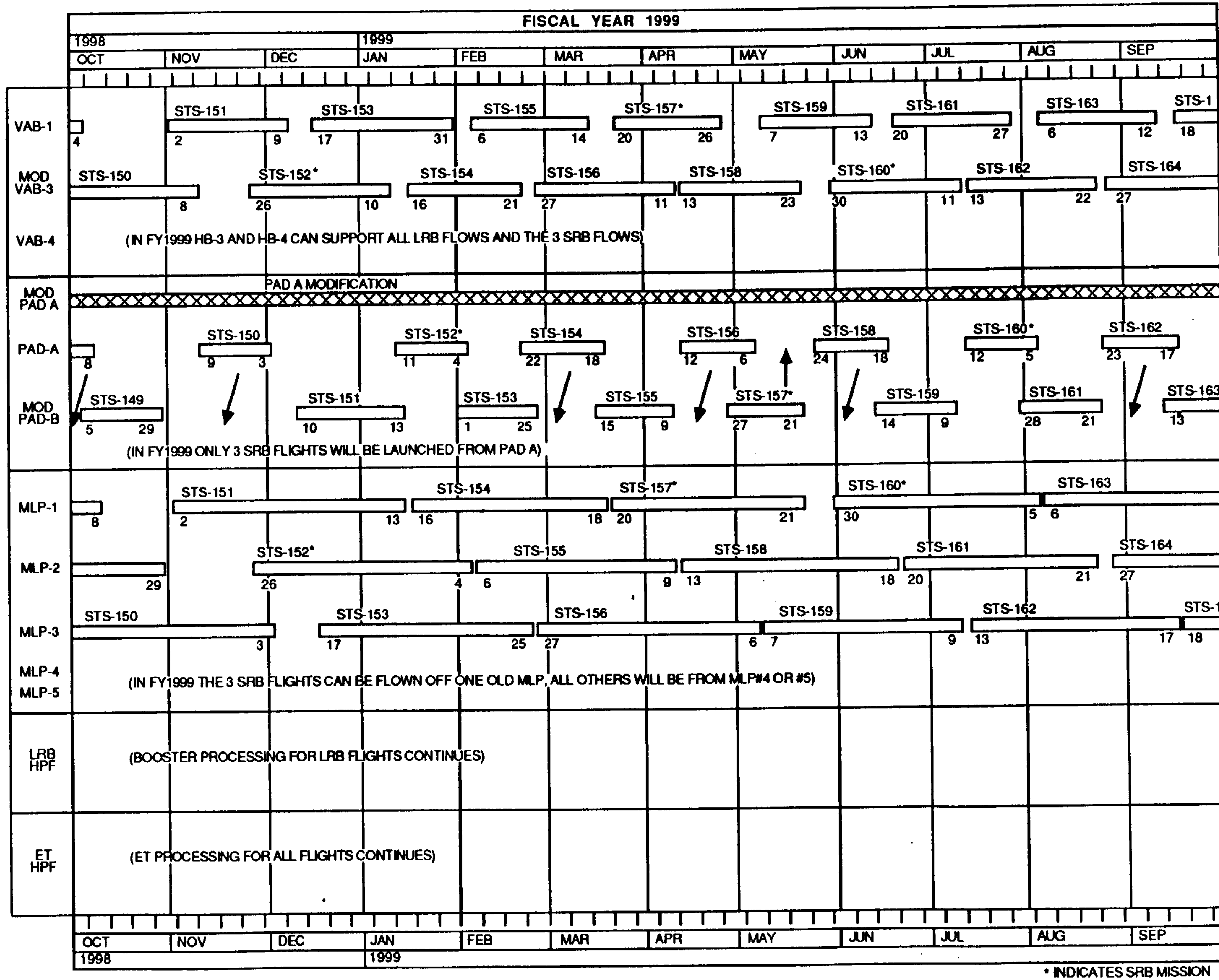


*LRB FLIGHT PROCESSING FOR STS-148 AND ON NOT RESCALE.

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Figure 2.6-11. FY1998 KSC SRB/LRB Processing Facility Utilization.

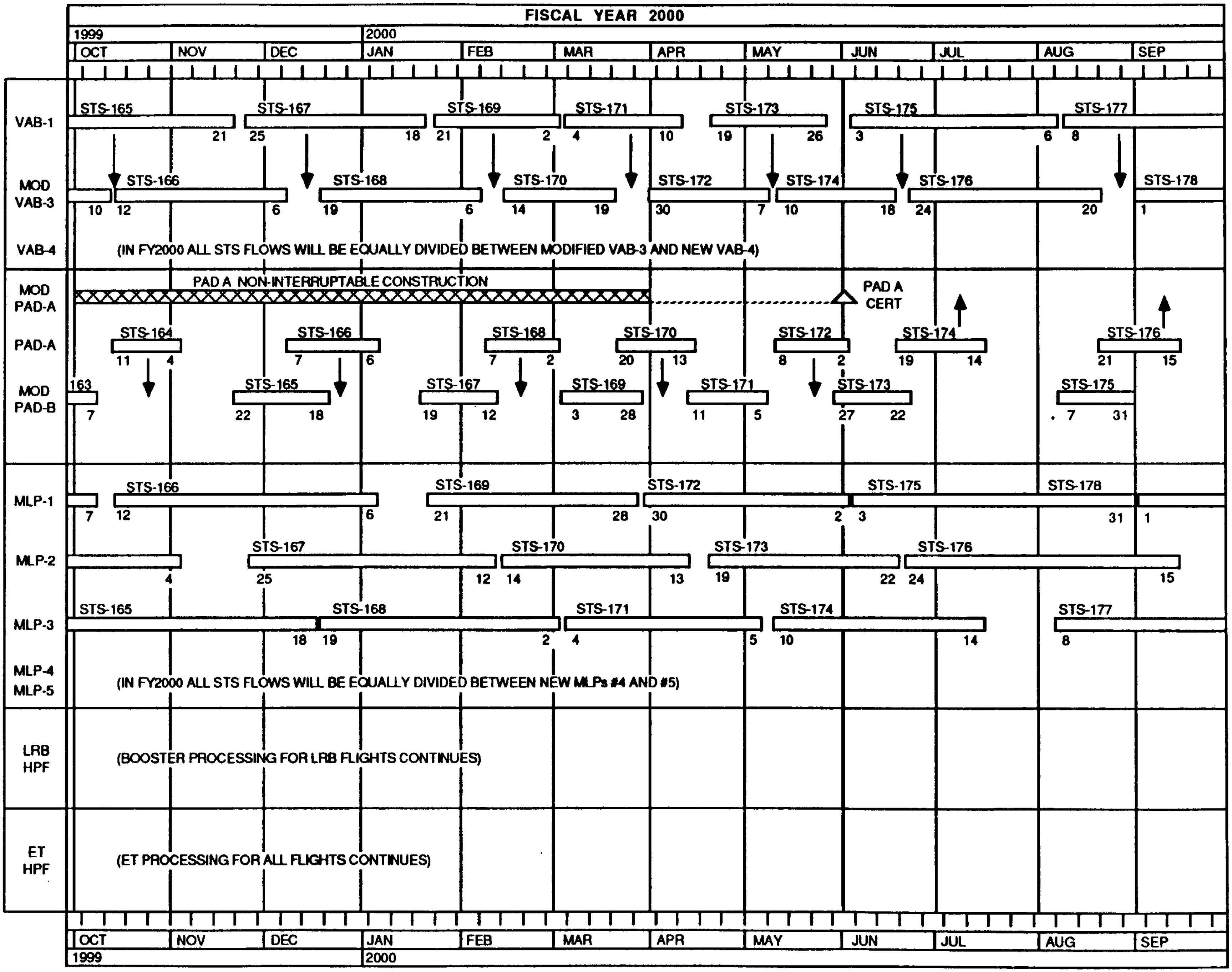
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Figure 2.6-12. FY1999 KSC SRB/LRB Processing Facility Utilization.

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Figure 2.6-13. FY2000 KSC SRB/LRB Processing Facility Utilization.

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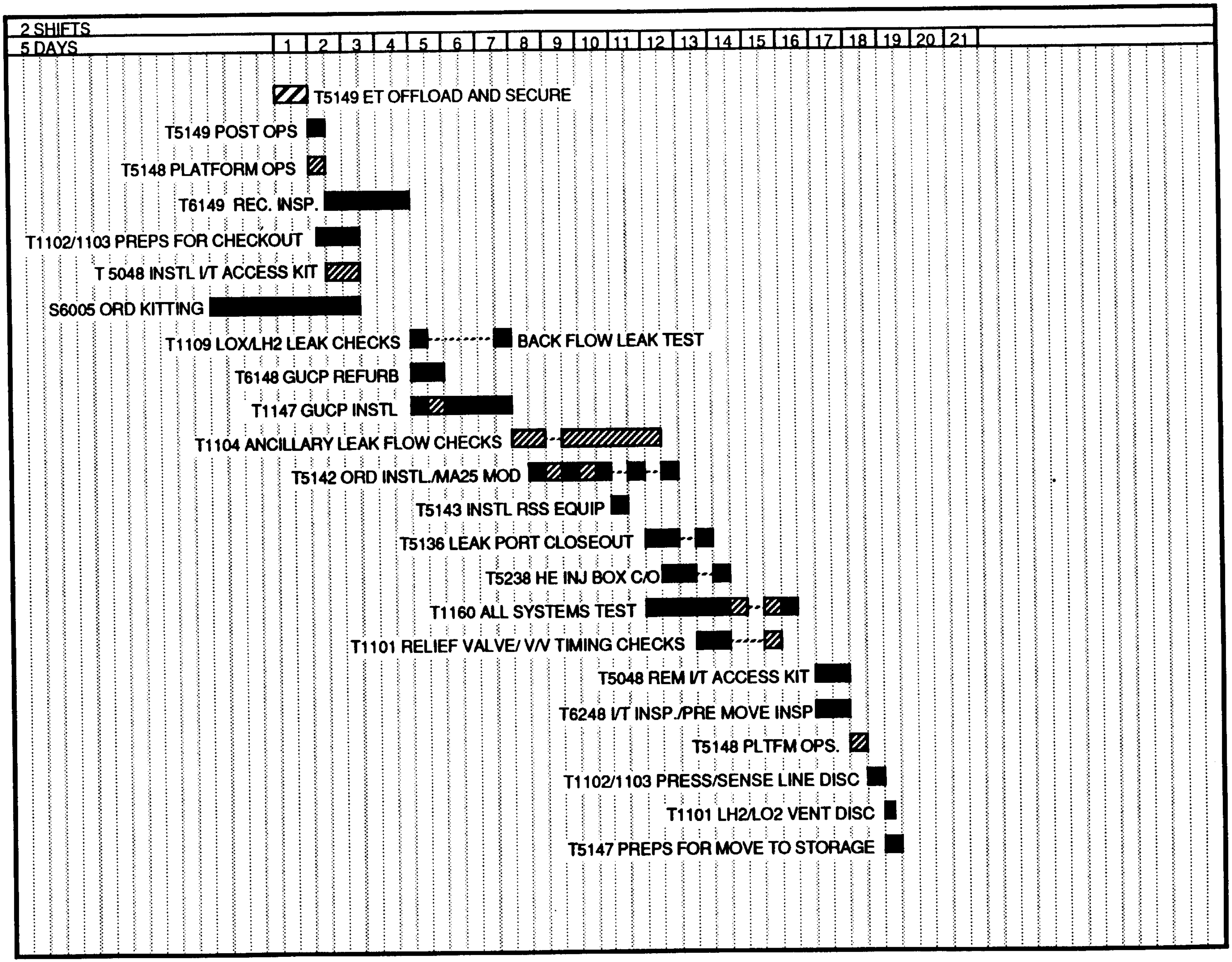
2.7 MODIFIED ET PROCESSING TIMELINES

The existing standalone ET processing tasks when relocated to the Horizontal Processing Facility will be modified somewhat to be achieved in the HPF with only a small amount of the work deferred to the integration cell after ET vertical mate. The revised standalone HPF Test/Checkout timelines are presented in Figure 2.7-1. The overall 20 day schedule is basically unchanged from that currently run in the vertical ET cells.

One major concern was the installation of the Ground Umbilical Carrier Plate (GUCP), OMI (T1147), in the horizontal mode. After conferring with Martin Marietta Launch Support Services (LSS) the following findings were provided:

<u>Ground Umbilical Carrier Plate - Horizontal Installation Feasibility</u>

- Horizontal GUCP installation is deemed feasible
- Access required for GUCP installation and new GSE is required for GUCP installation
- Access GSE could be cantilevered off the existing ET transporter (Modifications to ET transporter must meet barge and other processing constraints)
- Installation fixture required for lifting GUCP plate to ET (Weight approximately 130 lbs). Safety restrictions would probably not allow 2 or 3 technicians to lift the body of the GUCP.
- Hydrogen Quick Disconnect (QD) would require GSE fixture for lifting, aligning and installing (QD weight 50-60 lbs)
- A "Mini-GUCP" could be built for installation in the ET Processing Area. The Mini GUCP would be used during leak checks. The GUCP would then be installed vertically in the integration cell with remaining testing performed at that time. This optional approach would reduce integration cell testing. (2 shifts for installation of GUCP and 2-8 shifts for required checkout/leak testing)



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Figure 2.7-1. Revised ET Test and Checkout (Horizontal Processing Scenario).

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Issues Derived from Horizontal ET Processing

- Work required at launch site may be reviewed. Processing activities already performed at MAF (checkout/leak tests/etc.) in the horizontal position may not have to be repeated.

- Number of transporters required and configuration of transporters needs to be reviewed. Horizontal processing may require additional transporters to meet storage needs.

(Data provided by Martin Marietta Manned Space Systems, 10/18/88)

This installation of the GUCP in the horizontal at the HPF would prevent carrying about 220 manhours of leak checks and valve testing into the integration cell. The modified ET/SRB timelines for ET mate and closeouts are presented in Figure 2.7-2. The 17 inch disconnect measurement and adjustment (T1108) and aft hard point closeout (T5141) are the only two functions carried to the vertical integration cell. Both of these tasks can be performed in parallel with other ET mate and closeout activity without timeline impact.

2.8 KSC FACILITY ACTIVATION TIMELINES

ARTEMIS timelines for the facility modification and activation activities during the initial first line facility activations are shown in the three pages of Figure 2.8-1 through -3. Described here are the key design, construction, verification, OMD development and certification timelines from FY 91 leading up to ILC in FY 96.

Activities associated with the new MLP for LRB and its park site are presented. VAB/HB-4 conversion and associated crawler way mods are presented. The new ET and LRB Horizontal Processing Facility (HPF) is shown to be constructed in two stages. ET processing here will be required prior to the need date for LRB capability in order to evacuate the ET activity from HB-4 early in the activation schedule.

LETF and LCC/LPS modification schedules are shown. Finally, the first major Pad B mod for LRB is scheduled. Only the last eight months of the Pad construction before LRB certification is required to be exclusive access.

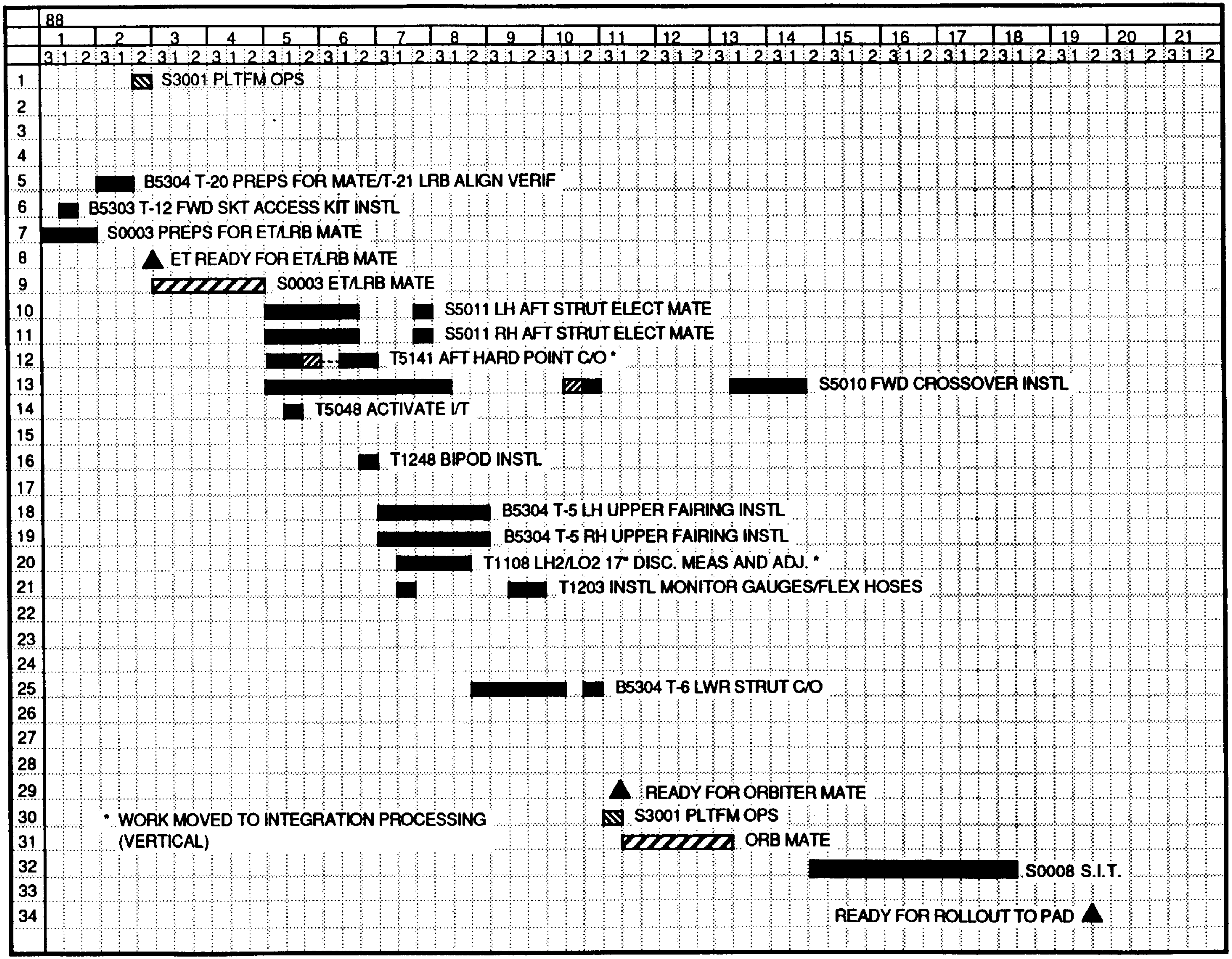


Figure 2.7-2. Revised ET/LRB Mate & C/O Assessment.

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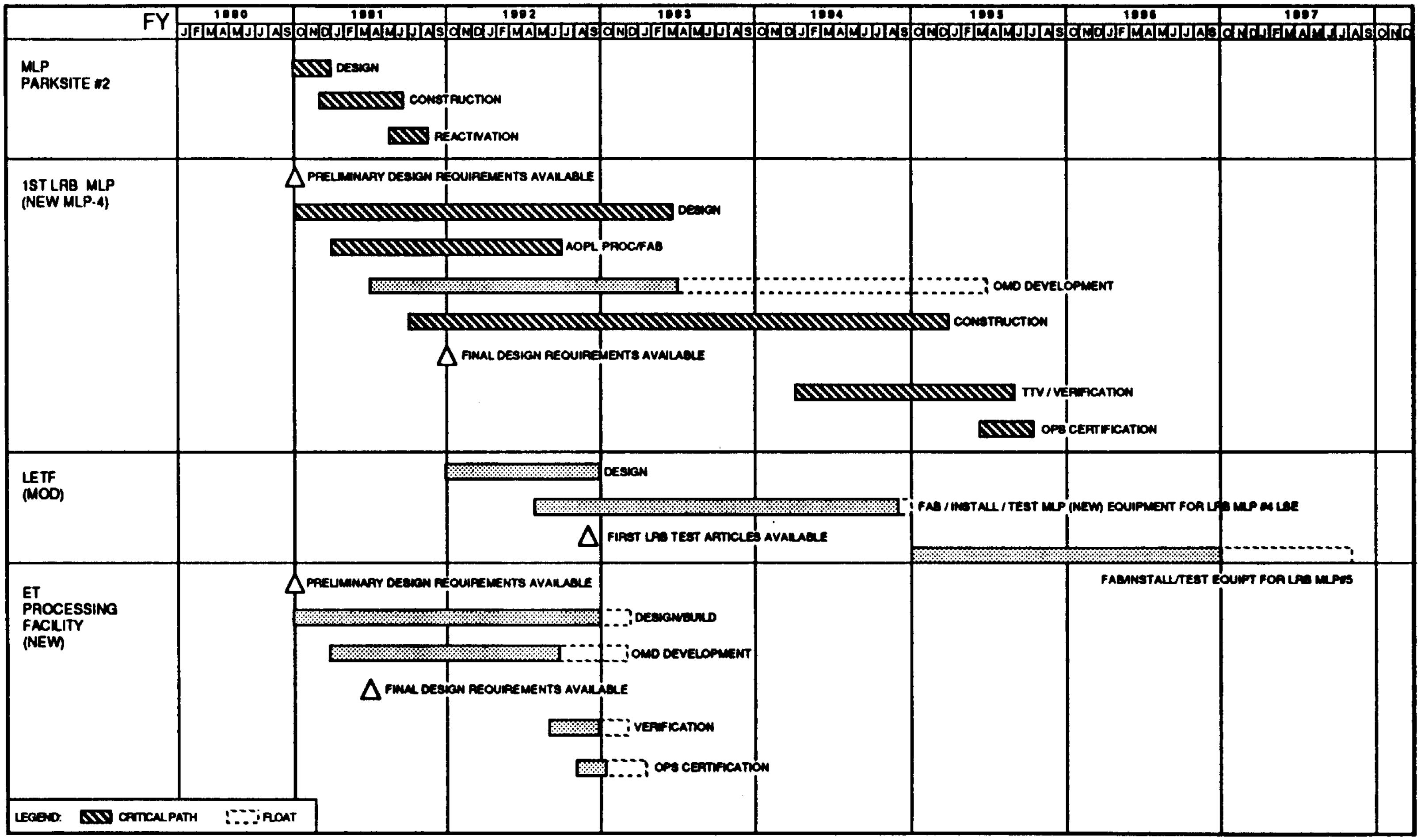


Figure 2.8-1. KSC Facility Activation (First Line) Page 1.

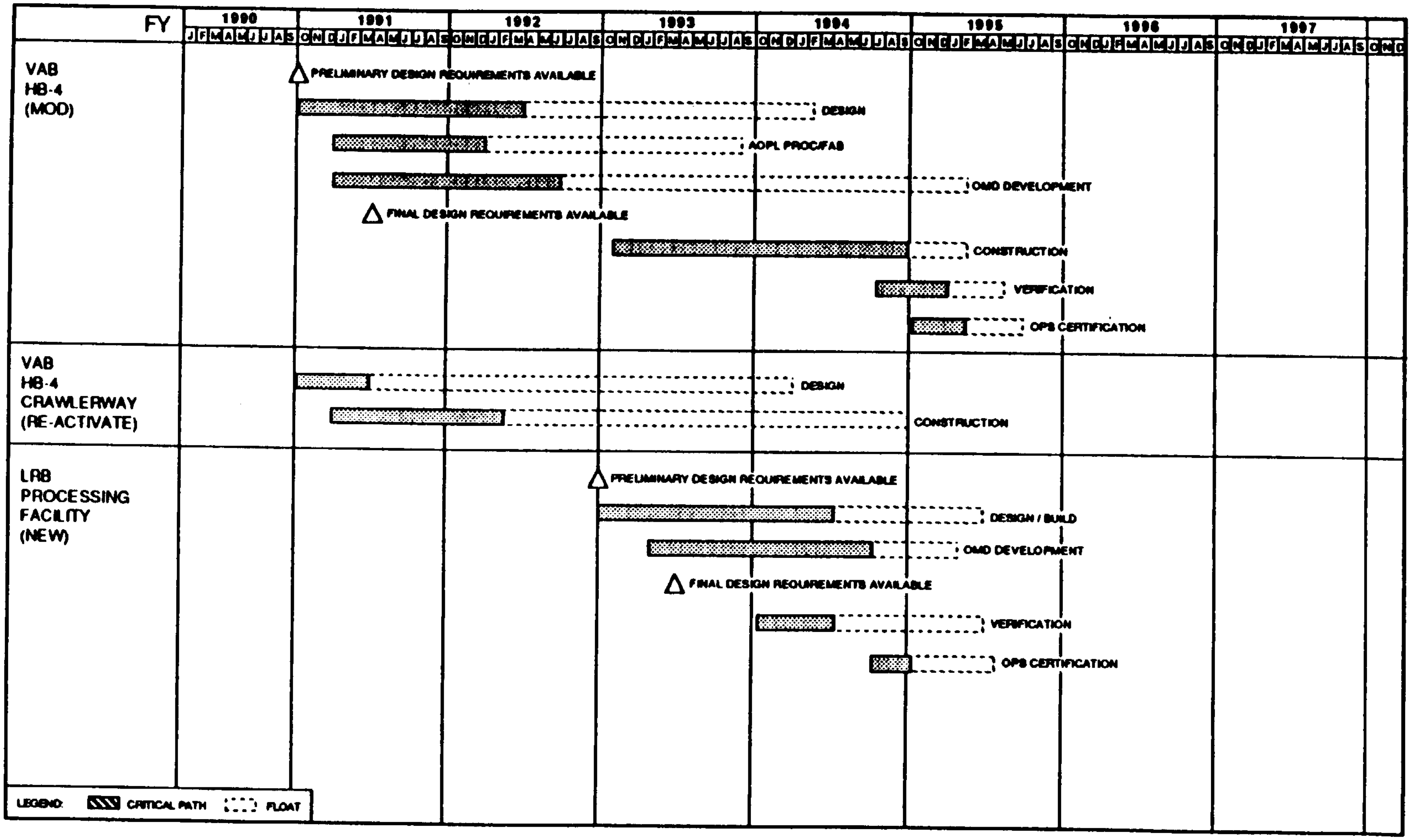


Figure 2.8-2. KSC Facility Activation (First Line) Page 2.

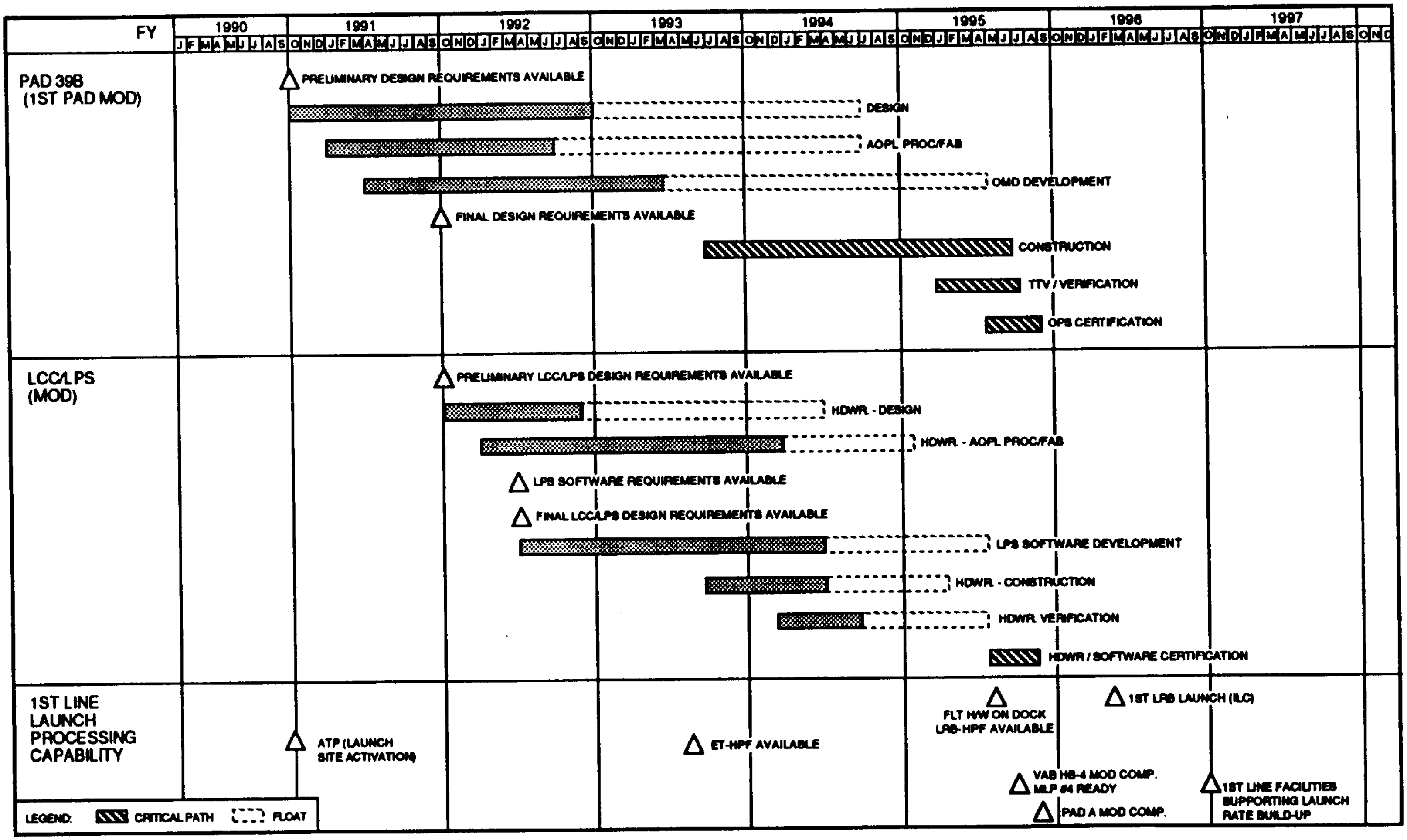


Figure 2.8-3. KSC Facility Activation (First Line) Page 3.

Facility activation schedules for the continued (second line) activations during transition (FY-96 to FY 2000) are shown in Figure 2.8-4. These activations will be required to achieve the LRB launch rate build-up. Included are the VAB/HB-3 conversion for LRB, the second new MLP construction and the second Pad (Pad A) modifications.

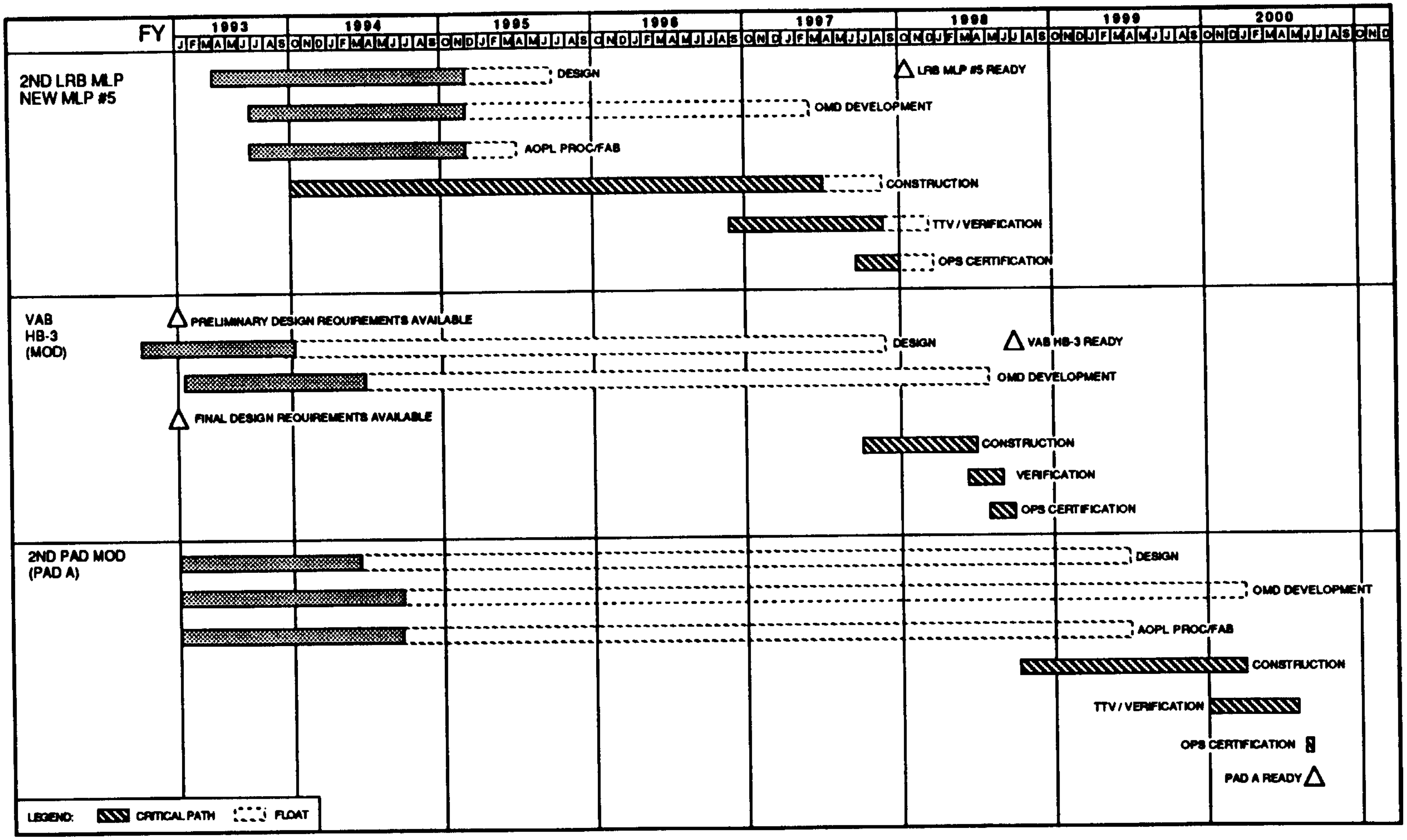


Figure 2.8-4. KSC Facility Activation (Second Line).

VOLUME III

SECTION 3

LRB FACILITY REQUIREMENTS AND CONCEPTS
FOR NEW FACILITIES

SECTION 3

LRB FACILITY REQUIREMENTS AND CONCEPTS FOR NEW FACILITIES

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LRB FACILITY REQUIREMENTS AND CONCEPTS FOR NEW FACILITIES

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SECTION 3

LRB FACILITY REQUIREMENTS AND CONCEPTS FOR NEW FACILITIES

This study product will develop the facility impacts of the various LRB concepts being developed by the two Marshall Space Flight Center (MSFC) phase-A contractors. Figure 3.0 lists the physical characteristics (size and weight) of the seven LRBs analyzed. The analysis will provide sufficient depth to compare the different LRB configurations to existing facility utilization and Space Transportation System (STS) flight element flow. Receiving, handling, processing, integration, prelaunch test and checkout, and launch of LRBs will be addressed in the facility requirements and impacts.

This study was accomplished by evaluating variables in LRB operational scenarios for each LRB configuration and providing recommendations and supporting rationale for LRB facility requirements. This evaluation includes transition impacts for an SRB/LRB mixed fleet and LRB processing requirements so that concepts for new facilities and concepts for current facility modifications can be made. Operational considerations for flight hardware processing were also used to analyze impacts to KSC facilities and existing operations.

Included in this study are impacts to various facility systems (ac power, communications, and operational communications system) with the introduction of the LRB at KSC. An evaluation and specific conceptual recommendations which would provide the capability to support the LRB and the Launch Processing System (LPS) will also be addressed.

3.1 ET/LRB HORIZONTAL PROCESSING FACILITY

This section of the study will address facility requirements for receiving, processing, and storing LRBs horizontally. An evaluation of the Vehicle Assembly Building (VAB) for this LRB function is presented in Section 19 of Volume III and activation, operational, and safety impacts are identified therein. The evaluation of the VAB concludes with a strong recommendation for receiving, processing, and storing the LRB in a stand-alone horizontal processing facility. Thus, this section will address the facility requirements as well as present the concept for a new LRB processing facility (which includes a test bay, storage bay, engine shop, and control room).

PROPERTIES	MMC		GDSS					SRB
PROPELLANTS								
OXIDIZER	LOX	LOX	LOX	LOX	LOX	LOX	LOX	SOLID
FUEL	RP-1	RP-1	RP-1	RP-1	LH2	CH4	LH2	
TYPE	PUMP	PRESSURE	PUMP	PRESSURE	PUMP	SPLIT/ EXPANDER	PUMP/FAT	
VEHICLE								
LENGTH (FT)	150.9	162.7	149.5	199.5	190.5	150.47	169.5	149.0
DIA (FT)	15.3	16.2	14.1	15.0	16.2	15.0	17.7'	12.3
SKIRT	22'-11-1/4"	26'-0"	25'-11-1/8"	26'-9-1/2"	22'-3-1/2"	27'-3-1/8"	24'-4"	-
WEIGHT								
GLOW	4,130,505	4,530,410	3,974,000	5,190,644	3,416,000	3,864,000	3,400,816	4,525,000
LRB (DRY)	116,665	199,520	114,039	227,533	119,523	104,132	104,339	198,000
LRB (WET)	1,092,000	1,300,860	1,015,195	1,633,178	736,111	960,164	720,932	1,300,356

Figure 3.0. Data for LRB Configurations.

The conceptual baseline for LRB processing requirements for test and checkout of LRB propellant systems and engines is addressed in paragraph 3.1.1. It should be noted that both MSFC phase-A contractors have accepted the design recommendation necessary to process and store the LRB horizontally.

3.1.1. LRB Horizontal Processing Requirements

This section will review the Shuttle's external tank (ET), the Orbiter's main engine and the SRB's avionic safety systems storage and checkout functional processing/test requirements currently performed in the Orbiter Processing Facility (OPF) and the VAB and will establish the conceptual processing/test functional requirements of a liquid rocket booster (propellant tanks and engines) in the new LRB/ET Horizontal Processing Facility. (HPF)

3.1.1.1 Methodology of Study

The methodoly of this study was to establish a comparison between the LRB pump-fed propellant system and the Orbiter/ET pump-fed propellant system processing operations since the ET and Orbiter engines contain similiar physical characteristics; e.g.thin wall constructed liquid propellant storage tanks, main engines, intertank access, a nose cone, a ground support equipment (GSE) interface, a tank/engine interface, and an exterior network of Shuttle Range Safety System (SRSS) ordnance and Thermal Protection System (TPS).

The approach was to define the conceptual functional processing and test requirements of LRB by analyzing the present day storage and checkout processing requirements of the ET and Orbiter's main engines and deduce the functional processing requirements for LRB storage and checkout processing.

3.1.1.2 Analysis

The LRB processing concept is presented in the paragraphs following and Figure 3.1.1.2 denotes the processing requirements that were defined and analyzed to develop the LRB propellant system and engine processing concepts.

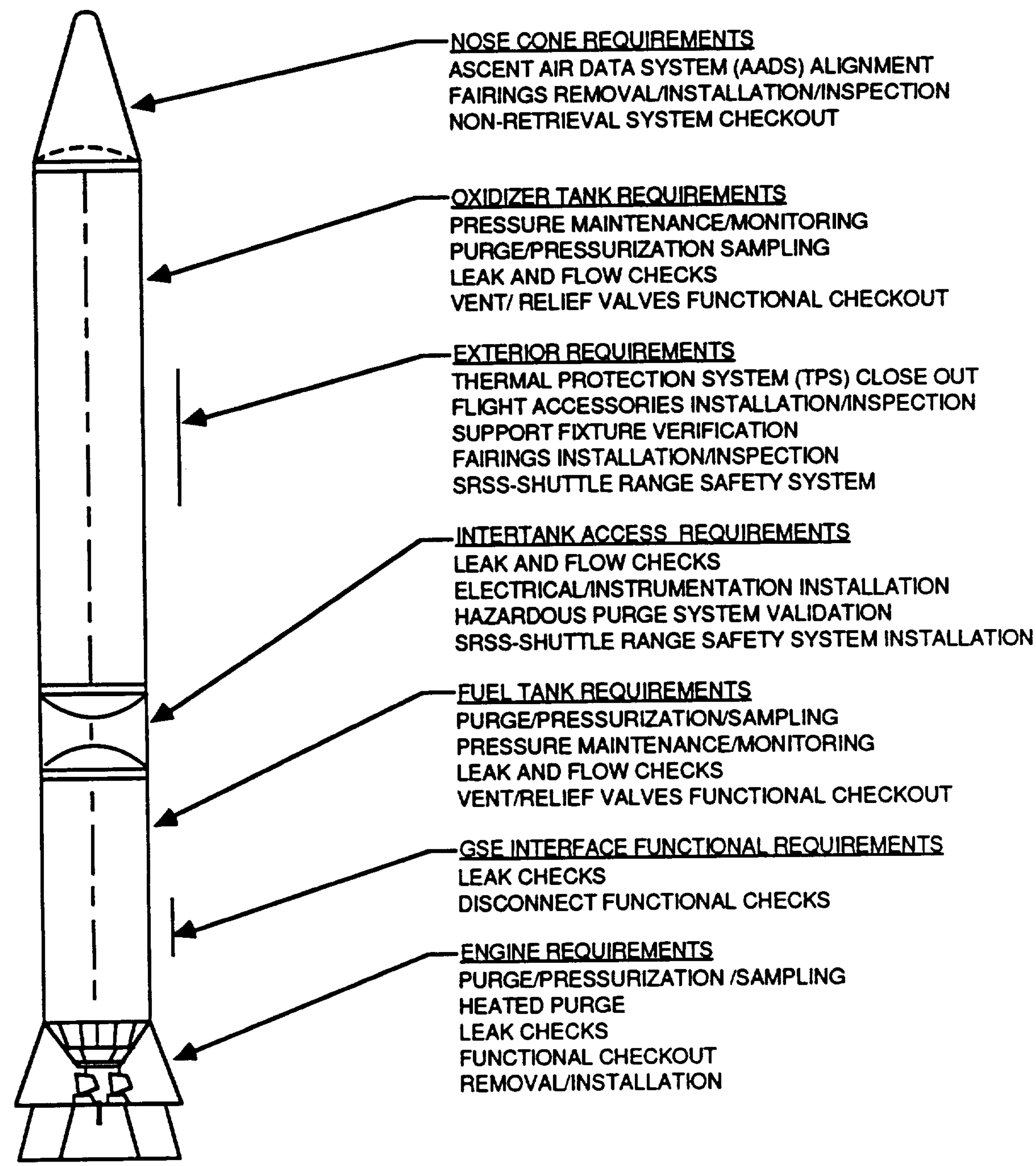


Figure 3.1.1.2. LRB Processing Functional Requirements.

Tank Pressure Maintenance and Monitoring

ET Baseline Review - Due to the thin-wall construction of the ET tanks, a major requirement of processing is prevention of tank deformation due to pressure differential between the tank and atmosphere. A positive tank pressure is therefore maintained and constantly monitored throughout storage and checkout processing operations. That positive pressure also satisfies a second important requirement: prevention of tank contamination. ET-dedicated pressurization/monitoring equipment, located in a tower between the storage and checkout cell, controls and distributes facility nitrogen and helium gases to each propellant tank feed line interface and thus satisfies both processing requirements.

LRB Conceptual Processing - LRB tank processing is perceived to be identical in all respects to the ET in that the propellant tank positive pressure monitoring and maintenance requirements will prevent tank deformation due to atmospheric pressure and will prevent contamination throughout processing operations. LRB-dedicated pressurization and monitoring equipment can control and distribute facility nitrogen and helium gases to each propellant tank feed line interface. Access for GSE hook-up can be achieved via portable or fixed platforms.

Tank Purge, Pressurization, and Sampling

ET Baseline Review - The main receiving and inspection requirements of the ET are to remove the shipping pressurization equipment, take a dew point sample, and, if required, repressurize each propellant tank. Samples are taken at the propellant feedline interface. If samples fail, then the tank is purged and repressurized for another sample. This operation requires a pressurization interface at the propellant feedline similar to the monitoring operation but also requires vent valve actuation during purging. Facility gas is regulated and distributed to the tank vent valve actuation interfaces at the intertank area.

LRB Conceptual Processing - LRB configurations for tank pressurization, purge, and sampling are perceived to be essentially the same as the ET processing baseline requirements. The LRB configurations should have the capability to hook up dew point sampling, purge, and pressurization equipment at the GSE fill/drain interface and have provisions for a vent valve actuation interface at the intertank area. Access for GSE hookup can be achieved via portable or fixed platforms.

Tank Leak Checks

ET Processing Review - After the ET has been prepared for processing, leak checks are performed on tank penetrations, flanges, and closures that are directly exposed to tank pressures. All mechanical joints of the feedlines and pressurization lines tank closures and the fuel vent valve/tank interface in the intertank are leak checked using a leak test collector counter connected to the joint leak test ports. Tank-associated transducers and electrical feed penetrations are bubble-leak checked. In the event it is necessary to pressurize the tanks to meet leak test pressure requirements, so the checkout pressurization GSE is required to be functional and ready to support. Access to these leak points is attained via the intertank area where a vertical intertank access kit is installed to reach some of the leak test ports. When personnel are working in the intertank, essential equipment for lighting, air conditioning, and oxygen monitoring are required.

LRB Conceptual Processing - LRB tank leak check processing is perceived to be identical in all respects to ET processing. To achieve access to the various leak points within the intertank access area, a horizontal access kit is required as well as the associated equipment for personnel safety and comfort. The locations of tank penetrations, flanges, and closures should be designed to permit local performance of leak check operations.

Tank Vent/Relief Valve Functional Checkout

ET Processing Review - In the checkout or storage cell, the ET tanks' remotely operated fuel and oxidizer tank vent/relief valves are operated by Launch Processing System (LPS) control in order to verify that the LPS actuation of the valves opening and closing is within specified timelimits and to verify that the relief valve pilot cracks and reseats within specified pressures. The LPS-controlled vent valve actuation panels and tank purging equipment (GSE) will interface with the ET via the intertank Ground Umbilical Carrier Plate (GUCP) and the ET/Orbiter umbilical.

LRB Conceptual Processing - LRB configuration for tank vent/relief valve functional checkout is perceived to be essentially the same as the ET tank vent/relief valve LPS control and functional processing baseline.

Intertank Access Area

ET Processing Review - Besides the intertank leak check operations previously identified, other work performed in the intertank access area is associated with ancillary local leaks of mechanical joints, flow verification checks of a network of tank isolated tubing, verification of electrical instrumentation, and installation and checkout of the SRSS.

LRB Conceptual Processing - The LRB configuration for processing systems in the intertank area is perceived to be essentially the same as for ET processing.

GSE Interface

ET Processing Review - ET checkout processing includes the functional checkout of the ground support umbilical interface. ET-related purges, pressurization, component actuation, and vent distribution lines are routed to the intertank area and connected to the flight half of a quick disconnect at the intertank GUCP. In the checkout cell of the VAB, the ground half quick disconnects are installed as part of the GUCP assembly, after which the total assembly is functionally leak checked and utilized for interfaces to facilitate checkout processing of the ET before vehicle integration .

LRB Conceptual Processing - The LRB configuration for processing requirements related to the GSE interface is perceived to be essentially as the same as for the ET. However, a horizontal installation and functional checkout of the GUCP assembly has never been performed. The immediate problems perceived for horizontal installation of the GUCP are in the method of installation, available clearances while LRB is on the transportation vehicle, and confidence in the functional checkout of the quick disconnects. Handling equipment to facilitate installation, sufficient clearance envelope from the transporter vertical support yokes, and testing to prove confidence in the functional integrity of horizontal checkout are required.

Tank/Engine Interface

ET Processing Review - The Orbiter's Space Shuttle Main Engines (SSMEs) and ET umbilical interface configuration consists of a 17 inch diameter disconnect valve on the Orbiter and an ET pressurization disconnect for both the fuel and oxidizer propellant systems. Critical measurement verification, sealing surface inspections, and sealing integrity are performed in the checkout cell.

A portable ultra-clean environment is required because the ET propellant tanks are directly exposed when the umbilical covers are removed to access the flapper valves for measurement verification. The ET checkout purge pressurization, sampling operations, and measurement e quipment are required to support this operation.

LRB Conceptual Processing - The LRB processing configurations are perceived to be different in respect to the tank/engine interface. A mechanical connection interface which would eliminate critical quick-disconnect measurements and inspections but retain the sealing surface inspection and leak test requirements is all that is required.

Exterior Surface

ET Baseline Review - The basic processing tasks performed on the exterior of the ET are to install and inspect all exterior pressurization lines and electrical cables, SRSS ordnance and instrumentation, and the TPS.

LRB Conceptual Processing - The functional requirements for LRB for exterior surface processing are perceived to be similar to the ET. Performance of processing requirements in the ET/LRB Horizontal Processing Facility depends on the locations of the exterior piping, electrical cabling, and SRSS ordinance. Any exterior routing paths should be adjacent to each other in order to allow for access by either one continuous platform or ground level.

Nose Cone Area

ET Baseline Review - The basic processing requirement for access to the nose cone is to allow for upper tank component processing, non-retrieval system (tumble valve) inspections, and verification of nose cone purges.

LRB Conceptual Processing - The LRB configuration for nose cone processing requirements is expected to be similar in respect to the upper tank vent valve functional checkout, nose cone purge verification and non-retrieval/ retrieval system inspection. Nose cone removal, as with the SRBs, can be performed with handling equipment and platforms (fixed or portable) which permit personnel to access for all related processing requirements.

Engine

SSME Processing Requirements Review - The processing of the SSMEs requires verification of the operational integrity of the main engines, the heat exchanger/GOX fluid systems, the GOX pressurization systems, the hot gas manifold, and the fuel and oxidizer feed system. Interface leak checks are also performed.

LRB Conceptual Processing - The functional requirements for LRB engine processing are perceived to be similar to the SSMEs. Performance of processing requirements in a horizontal facility depends upon access for GSE interface with engine systems.

3.1.1.3 Conclusions and Recommendations

This analysis of the ET provides the basic processing requirements for a Liquid Rocket Booster. The capability to perform these operations in a horizontal processing facility are summarized as follows:

Tank Processing The LRB propellant tanks will require tank pressure monitoring, purge, vent valve actuation, and pressurization capability to safe and prepare tanks for checkout processing. The number of tank penetrations and associated mechanical connections in the LRB's distribution system should be minimized and their locations made to be easily accessible for local leak check operations in the horizontal positions.

GSE Interface Checkout of vehicle launch-related GSE interfaces requires further study to resolve installation problems associated with the LRB GUCP assembly installation, handling, and integrity tests. Design requirements for the LRB transporter to satisfy the GUCP installation can eliminate and resolve these problems.

Nose Cone Handling equipment and access platforms are required to remove the nose cone, check-out the upper tank components, and perform purge verifications and other nose-cone related operations.

Exterior Surface Access for exterior surface processing requirements, such as SRSS ordnance installation, TPS installation and repair, and electrical/pneumatic distribution system routing, should be provided from platforms or ground level.

LRB Engines LRB engine processing requires access to the GSE engine interfaces. Access to engine Line Replacement Units (LRUs) must also be considered. Retractable platforms for engine removal/installation must also be provided.

3.1.2 ET Horizontal Processing Requirements

This section will review the ET processing requirements and determine the capability and impacts for processing an ET horizontally. (See Section 19 of Volume III)

3.1.2.1 Groundrules and Assumptions

The ET will be processed while installed on an ET transporter in the new ET/LRB Horizontal Processing Facility.

3.1.2.2 Analysis

The following paragraphs and Figure 3.1.2.2 describe the processing requirements that were analyzed to define an ET horizontal processing facility.

ET Nose Cone Requirements

The operations performed in the nose cone area include removal of shipping covers, removal/installation of the nose cone fairing to verify flow in the hazardous gas purge system, and inspection of the nonretrieval system (tumble valve). These operations can be performed horizontally if cone handling/removal equipment is provided.

ET Intertank Requirements

The fuel oxidizer tank ancillary leak checks, hazardous gas detection system verification, electrical instrumentation, and range safety installation and inspection operations performed in the intertank access area require an intertank access kit, breathing air support, environmental control system, and portable lighting equipment. The present ET operational checkout uses a vertical intertank access kit for intertank entry. Intertank access in the LRB/ET Horizontal Processing Facility would require the use of a newly designed horizontal access kit similar to the one used during the fabrication of an external tank at Michoud, Louisiana.

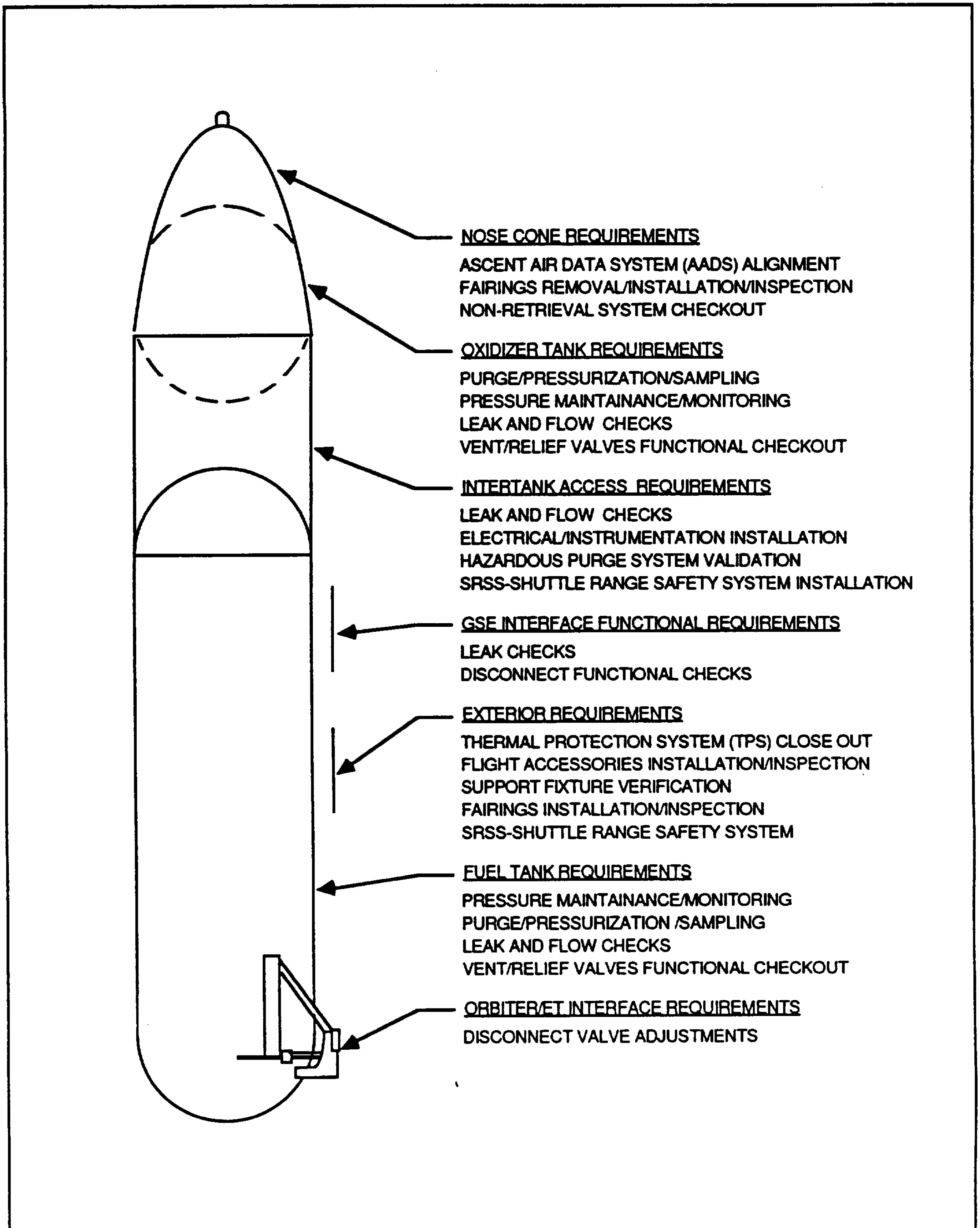


Figure 3.1.2.2. ET Processing Functional Requirements.

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ET Exterior Surface Requirements

The exterior surface can be reached by fixed or adjustable platforms to set up operational support equipment for inspection and repair of the thermal protection system and SRSS. A platform along the longitudinal axis of the ET will facilitate accomplishment of tank pressurization/feed line inspections; electrical cable installation and routing; and TPS closeout requirements for related equipment. Inspection and repair to the TPS atop the ET will be difficult to perform without subjecting the ET TPS exterior to the hazards associated with working heights; e.g. falling tools, debris, etc.

GSE Interface Processing Requirements

The GUCP installation would require a special study to define the special handling equipment and/or optional methods necessary for horizontal processing. Installation of the GUCP may be required to be performed after integration in the VAB. Functional and leak-check verifications of the GSE/ET quick disconnects are contingent upon the method chosen for installation. There has never been a GUCP interface installation on the ET while the ET has been on the transporter.

Orbiter/ET Interface Requirements

Access to the Orbiter/ET interfaces can be attained by installing platforms where various checkout operations can be performed, such as purge barrier installation/inspection/repair, pressurization lines disconnect sealing surface inspections, removal of shipping and standby pressurization GSE, and TPS inspection/repair/closeout.

Leak checks and functional verification of quick disconnects may be accomplished, but the measurement verifications and sealing surface inspections associated with the tanks' LH2 and LO2 flapper valves are considered very hazardous because of the possibility of contamination. Unless a new method for adjustments is devised, the flapper valve operations should be performed vertically after stacking on the MLP.

Tank Processing Requirements

Tank processing will require a GHe and GN2 facility gas supply system consisting of regulation control panels; vent valve actuator panels; portable regulation stations; leak, sampling, and oxygen

monitoring equipment to support the pneumatic purge; pressurization, leak checks, and sampling of the ET tanks; and functional verification and leak checks of the tank vent valves and relief valves. This system would require LPS control to actuate the vent valves during any tank pressurization and purge operations.

3.1.2.3 Conclusions and Recommendations

The ET tank's processing operations in a horizontal configuration would require GSE and operational procedures similar to those currently in use. The interfacing of this equipment to the ET would require access stands, fixed platforms, and portable platforms. The horizontal installation and checkout of the GUCP is questionable due to lack of workspace and clearances when the ET is on the transporter; modification of the transporter would be required to enable the GUCP to be installed in the horizontal position. A new checkout GSE interface might be required to support tank processing. The verification measurements performed on the ET/Orbiter, LOX, and hydrogen flapper valves should be performed vertically after stacking on the MLP to protect the inner tank from contamination.

3.1.3 ET/LRB Horizontal Processing Facility Concept

This section provides facility requirements, layout, and siting of an ET/LRB Horizontal Processing Facility. The facility concepts for processing and storing ETs and LRBs will be presented, as well as requirements for facility systems and utilities such as pneumatics, Environmental Control System (ECS), and electrical power. A trade study for a suitable siting location based on logistics, environmental impact, and safety concerns is included.

3.1.3.1 Facility Concept

The new offline facility will provide the capability to process two ETs and two LRBs and to store two ETs and four LRBs horizontally. (See Figures 3.1.3.1-1 and 3.1.3.1-2.) Shop areas are provided for engine, battery, TPS, and electronics/avionics activities. The processing bay will provide crane support and space for GSE; platforms and structures required for access and installation; and removal of engines, LRUs, and other components and subsystems. Final checkout of components and subsystems of the LRBs and ETs will be conducted on the HPF. Areas for logistics,

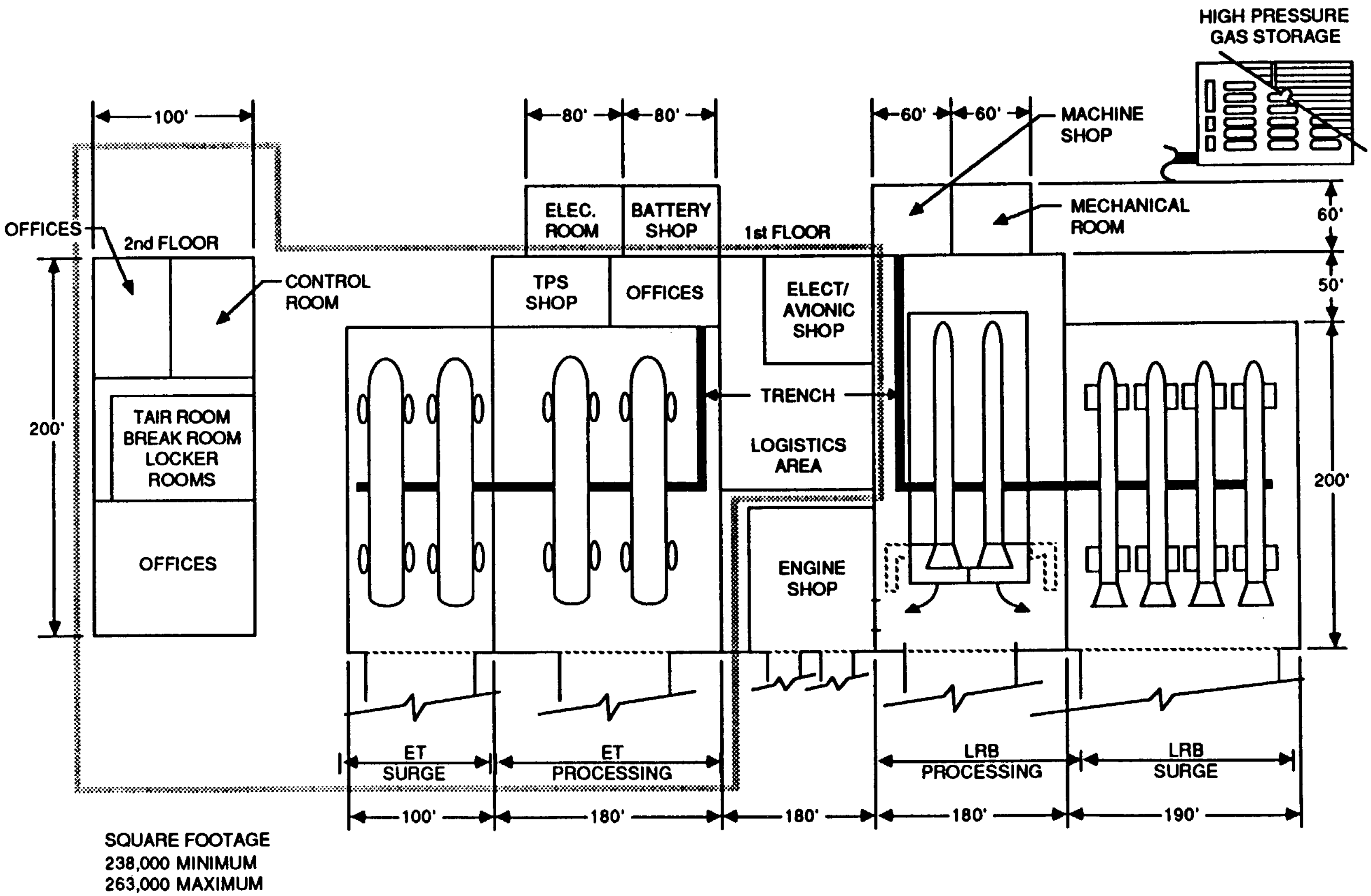


Figure 3.1.2.1-1. ET/LRB Horizontal Processing Facility Layout Plan.

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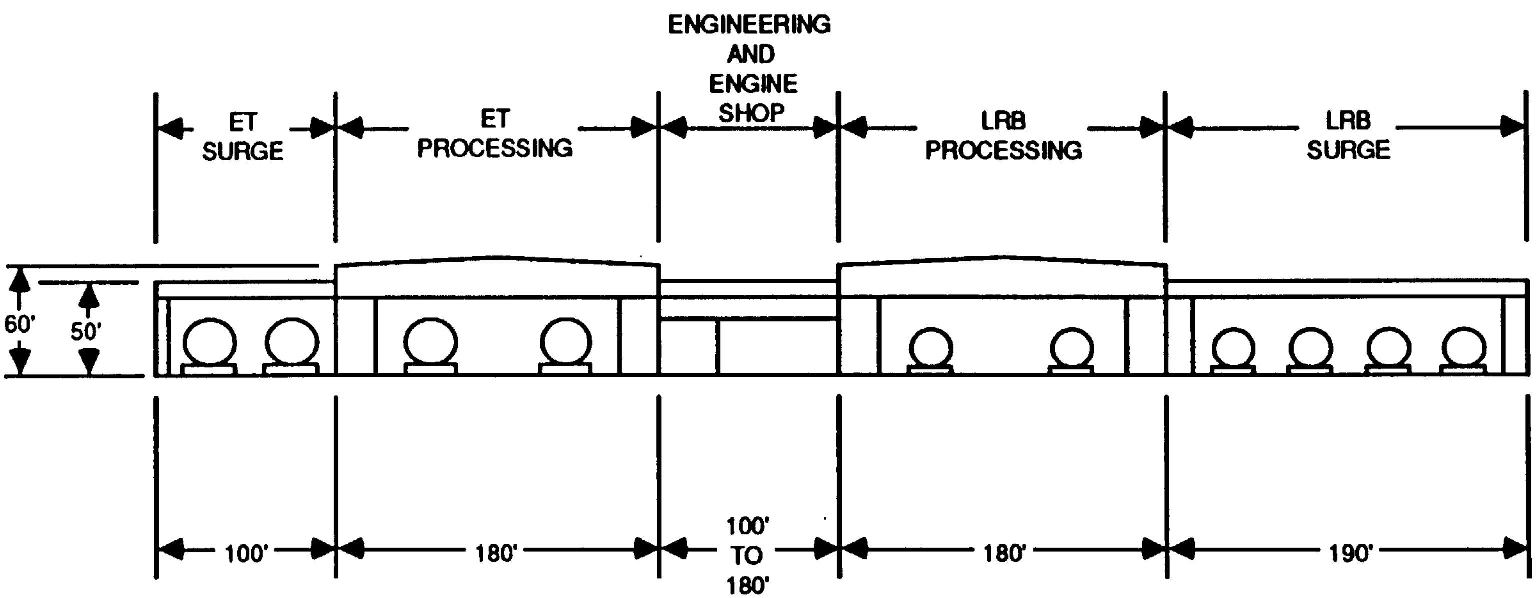


Figure 3.1.3.1-2. ET/LRB Horizontal Processing Facility Elevation.

GSE and LRU storage, office, and control room are provided. Space is provided for facility electrical and mechanical equipment, and there will be a high pressure gas storage area for helium and nitrogen. Floor trenches in the high bay areas are provided for cable and gas piping runs.

3.1.3.2 Facility Requirements

The facility requires the following utilities for processing and storage.

Pneumatics - Gaseous helium and nitrogen at 6000-psi supply pressures are required for processing and storage and will be supplied from the new high pressure gas storage facility. This facility will contain twenty 200-cu-ft (water volume) tanks of helium and the same for nitrogen. A shelter is required to protect the tanks from the environment. Shop air is required and will be supplied by a compressed air unit located in a utility annex at the HPF Facility. Specific pneumatic GSE requirements for ET and LRB processing and storage are covered in section 5.

Electrical - AC, DC, Uninterrupted Power System (UPS), and emergency 60-Hz power will be required. Specific power requirements for the facility are provided in paragraph 3.8.

Heating, Ventilating, and Air Conditioning (HVAC) - Standard heating, cooling, and humidity control are required for office and shop areas as well as in the ET and LRB processing and surge areas. An environmental control system (ECS) is required for personnel in the LRB bays for processing the skirt, mid-body, and nose purges.

Fire Control - Standard sprinkler systems are required in office, shop, and HPF bay areas. The Control Room will require a Halon system and the Battery Shop will require a chemical system.

Communications - A public address system, an Operational Communications System (OIS), and a voice recorder system are required.

Water - Potable water, Firex/deluge water and safe waste systems are required for the facility. A separate hazardous waste retention system is required for the battery shop.

Cranes - Two 30-ton cranes are planned to support processing activities in the LRB HPF bay.

3.1.3.3 Siting

Selection trade studies were conducted for four possible LC-39 sites (Figure 3.1.3.3-1):

1. South of the SPC Logistics Facility on Contractors Road
2. South of the Turn Basin adjacent to the Press Site
3. Southwest of the VAB and east of the Multi-Purpose Facility (MPF), (currently a parking lot)
4. North of the VAB and east of the Orbiter, Maintenance, and Processing Facility (OMRF)

The existing press site location is recommended, since it best satisfies the majority of the selection criteria. (See Figure 3.1.3.3-2.) The location would be in close proximity to the VAB, barge terminal, existing tow route to the VAB, and existing facilities and services. The site is beyond the VAB quantity/distance area and outside the currently defined launch danger area. (See Figure 3.1.3.3-1.) LC-39 traffic congestion would not be significantly increased. Tow route construction would be at a minimum. Site preparation costs would be minimized because this area is currently utilized and has already had environmental impact studies performed. A minimum of demolition and relocation of facilities is required.

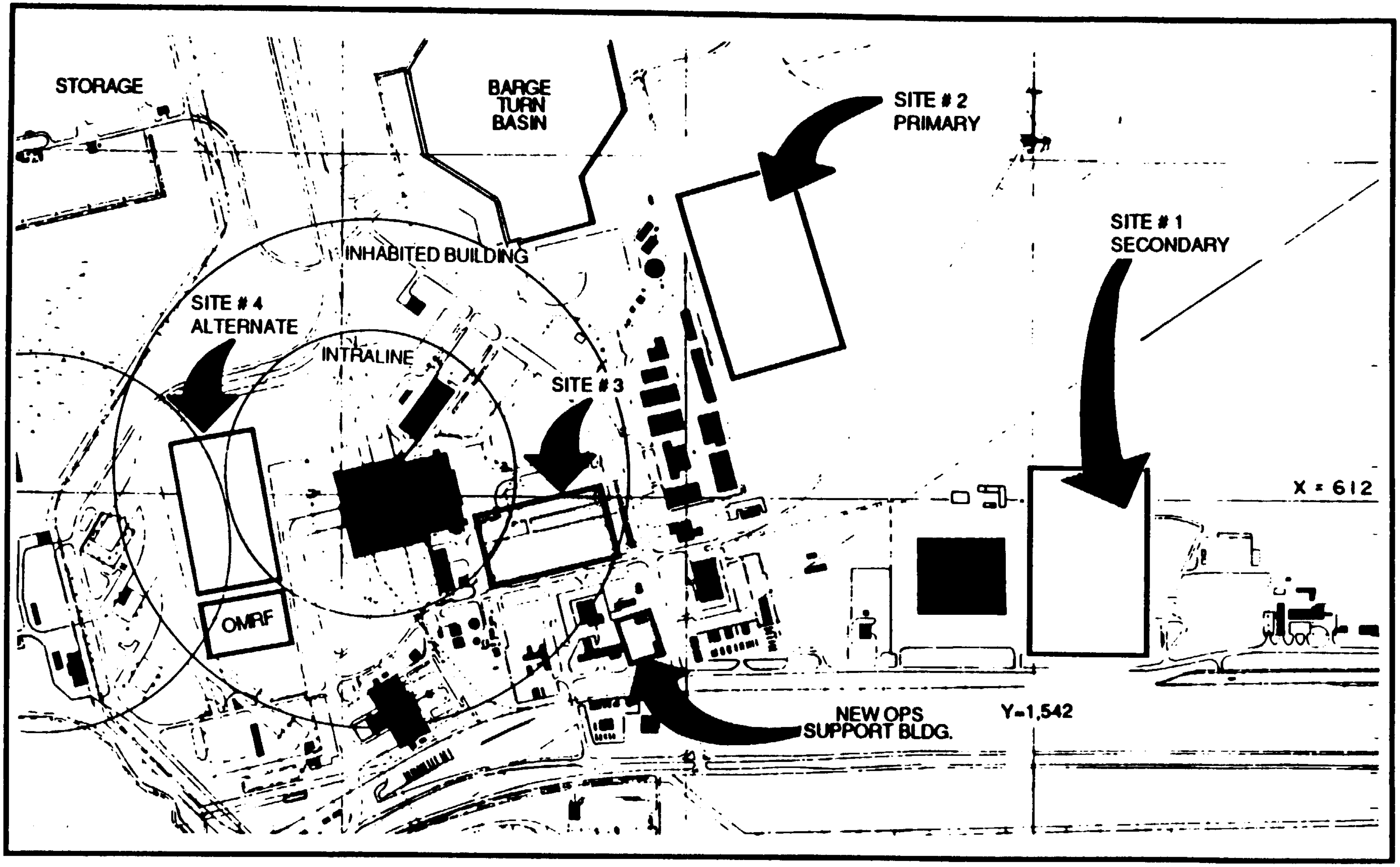
3.1.4 ET/LRB Horizontal Processing Facility - Control Room Requirements

This section defines the hardware and software checkout requirements for the HPF and establishes their impacts.

3.1.4.1 Requirements

Use of the Firing Rooms in the Launch Conrol Center (LCC) to perform testing can be ruled out. Based the amount of ET testing and estimates of new LRB systems that are expected to undergo testing prior to flight, the increase in Firing Room requirements would be greater than could be provided by the existing equipment and site without impacting Shuttle operations.

An independent Control Room will be provided in the HPF for the performance of all pre-mate checkout. The new Control Room will be like a mini-Firing Room for initial testing of LRBs and ETs soon after their arrival or subsequent to any maintenance, repair, or modifications that may be required at KSC. Testing will include functional tests of engine components, Thrust Vector



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Figure 3.1.3.3-1. ET/LRB Horizontal Processing Facility Site Plan.

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PRIMARY TRADE SELECTION CRITERIA	SITE 1	SITE 2	SITE 3	SITE 4
SSV INTEGRATION FACILITY PROXIMITY	NG	GOOD	GOOD	GOOD
TURN BASIN PROXIMITY	NG	GOOD	NG	NG
BLAST DANGER AREA (QUANTITY/DISTANCE)	OUT	OUT	IN	IN
LAUNCH DANGER AREA	OUT	OUT	OUT	OUT
ENVIRONMENTAL IMPACTS	YES	NO	NO	NO
ET & LRB TOW ROUTES PROXIMITY	NG	GOOD	GOOD	NG
LC-39 AREA CONGESTION (INCLUDING TRAFFIC)	GOOD	GOOD	NG	NG
AVAILABILITY OF UTILITIES/SERVICES	NG	GOOD	GOOD	NG
DEMOLITION AND RELOCATION OF EXISTING FACILITIES	NO	YES	YES	NO
SITE PREPARATION COSTS	LOW	MED	MED.	LOW

LEGEND:

NG = NOT GOOD

MED = MEDIUM

Figure 3.1.3.3-2. Primary Trade Selection Criteria for LRB Horizontal Processing And Storage Facility Siting.

Control (TVC) controls, avionics, instrumentation, and power systems on the LRBs. Similar testing of ET systems currently performed in a VAB high bay will also be performed.

The Control Room will require six Launch Processing System (LPS) computer consoles (similar to the LCC Firing Rooms). Figure 3.1.4.1 illustrates the room layout. Ten systems will share four system consoles (each console containing three CRTs), thus providing three work stations per console. The remaining two consoles will be designated as the master and integration consoles (again, in an operation similar to the current Firing Rooms). Additional equipment will be required to support the Control Room such as Hardware Interface Modules (HIMs), Front End Processors (FEPs), data recorders, communications and uninterruptible power supplies.

Software currently used for testing the ET will be used in this control room as well. Software will have to be written to support test and checkout of the various LRB subsystems. Application software that will address which vehicle is undergoing pre-flight test and checkout will also have to be developed. The design for the HPF Control Room calls for the use of LPS-type consoles similar to the ones used in the LCC Firing Rooms. These consoles are no longer manufactured, and therefore it is imperative that the LPS replacement system (LPS-2), currently in the planning stages, be used to supply the equipment necessary to construct this Control Room.

Completion of LPS-2 is planned for approximately 1991 as a replacement and upgrade of the existing LPS equipment. There would be an additional benefit derived from a commitment to the use of LPS-2 equipment for this Control Room. This benefit comes from the one-time-only expense incurred by installing LPS-2 model equipment and not having to special-order the existing type and later being faced with an upgrade to LPS-2 type.

3.1.4.2 Conclusions and Recommendations

The concept of having a Control Room in the HPF separate from the LCC Firing Room is ideal primarily because it would support parallel Shuttle processing and LRB processing.

It is strongly suggested that LPS-2 be committed to supplying the HPF Control Room LPS equipment. This is recommended from both an initial fabrication cost and from a recurring/replacement cost. If the LPS equipment is upgraded to LPS 2 at a later date, a significant processing schedule impact could be the result.

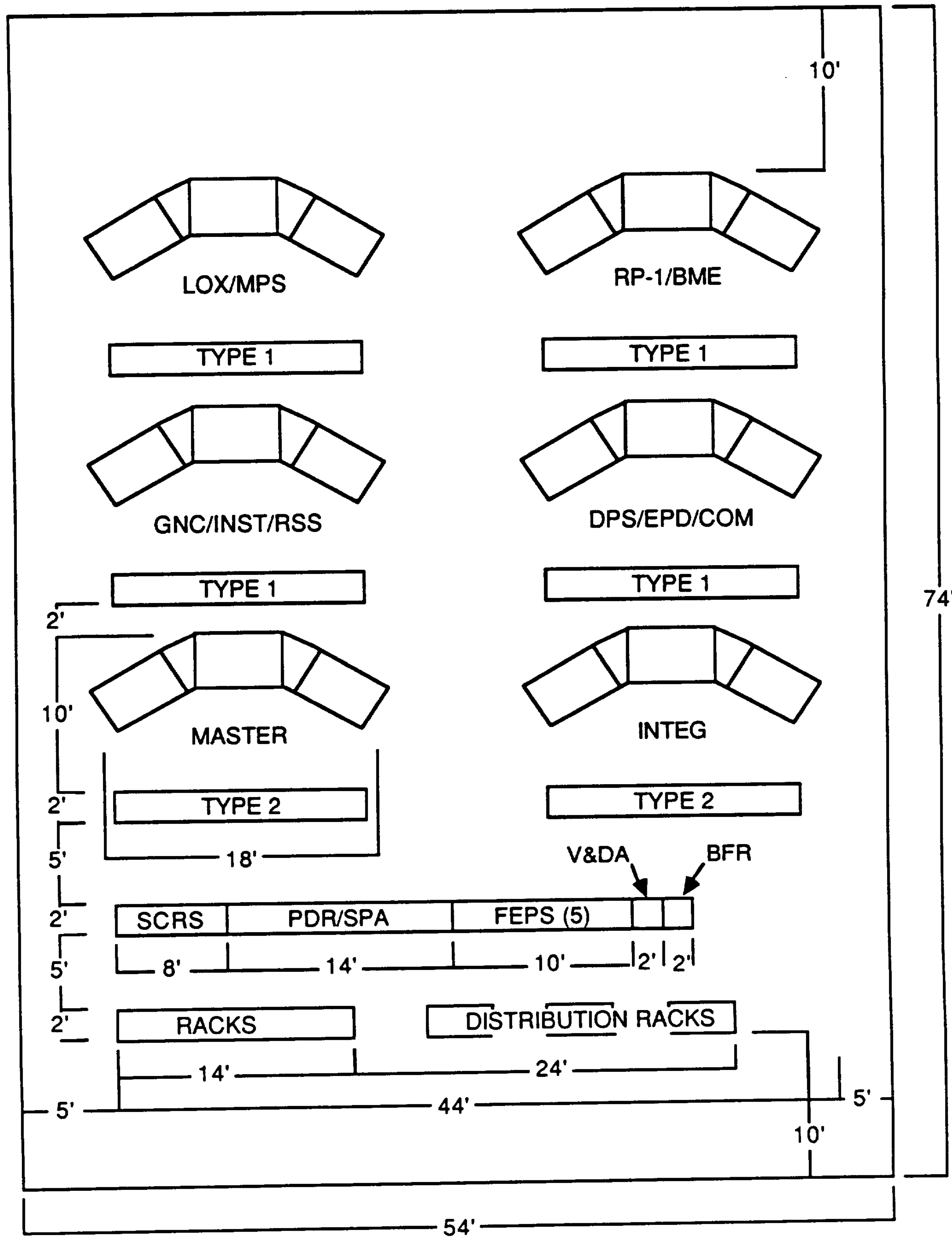


Figure 3.1.4.1. ET/LRB Control Room

3.2 VAB - INTEGRATION FACILITY

The VAB currently is used for storage and checkout of ETs in High Bays 2 and 4 and stacking and processing of the Shuttle flight elements in High Bays 1 and 3. This section will review and describe the impacts of introducing liquid rocket boosters into the VAB for integration. Also addressed is the reactivation of the Crawlerway to High Bay 4.

The processing scenario presented in Section 1 provides the concept of moving the ET processing out of High Bays 2 and 4 and utilizing High Bay 4 as an LRB/SSV integration cell.

The MMC LO2/RP1 pump-fed booster (as a small LRB) and the GDSS LO2/LH2 (as a large LRB) were chosen to describe the effects and to evaluate solutions. Other booster concepts are tabulated to indicate the deltas (differences).

Access requirements for the LRB would be based on an ET with four engines; therefore, an LRB can be modeled on the existing access requirements for ET processing during the integration operation.

The minimum clearance of six inches between hard steel and flight hardware must be maintained.

High Bay 4 would be refurbished to process the STS with LRBs before modifying High Bay 3 for dual capability processing. However, analysis of High Bay 3 is presented first in Paragraph 3.2.1. Presenting High Bay 3 will provide a clear understanding of the required ET and Orbiter access requirements and the High Bay 3 platform design which will be the baseline of the High Bay 4 access required.

3.2.1 VAB High Bay 3 Access Requirements

This section provides an evaluation of High Bay 3 extensible platforms and the modifications required to support the dual capabilities of processing SRBs and LRBs. At the present time, High Bay 3 is used to process SRB/SSVs. The extensible platforms are extended to conform to the SRB envelope with additional access provided by auxiliary platforms.

3.2.1.1 Description of the Present STS (SRB, ET, and Orbiter) Processing

For general arrangement of current access, see Figure 3.2.1.1.

SRB - Currently, the SRBs are built up and processed in the Rotation, Processing, and Surge Facility (RPSF). The segments are transported to the VAB Transfer Aisle, lifted, and stacked on the MLP. Each segment field joint requires access for technicians to install the interface mounting hardware for four segments. Other access is also required for the ET support struts.

External Tank - Currently, the ETs are stored in High Bays 2 and 4. How the operation is handled depends on which integration High Bay (1 or 3) and which checkout Bay (2 or 4) is used. Case in point: An ET is to be stacked in High Bay 1 and is stored in High Bay 4. The lifting procedure is as follows: Lift from checkout cell to transporter in Transfer Aisle, relocate transporter to High Bay 1 and lift for stack, prepare for soft mate to SRB forward segments, and install support struts.

Orbiter - The Orbiter is processed in the OPF, rolled to the VAB Transfer Aisle, and lifted to stack on the MLP where support struts to the ET tank are installed.

3.2.1.2 Proposed STS with LRB

The LRB booster would be lifted and stacked on the MLP hold down system. The attach strut locations would be the same as exist for the SRBs. Therefore, SRB access platforms can be modified for a dual capability. See Figures 3.2.1.2-1 and 3.2.1.2-2.

Only three major areas require access for LRBs:

Engine and Aft Skirt Area - The access would be similar to the Orbiter SSME engine service platform installed in the exhaust hole on the MLP. See Paragraph 3.3.3.

Intertank Area - The intertank access hatch and Umbilical Interface Panel require access during the processing operation. Impacts to extensible platforms are covered in Paragraph 3.2.1.3.

Nose Cone Avionics - Technicians require access to the Nose Cone area to perform tasks during the processing operation. Impacts to extensible platforms are covered in Paragraph 3.2.1.3.

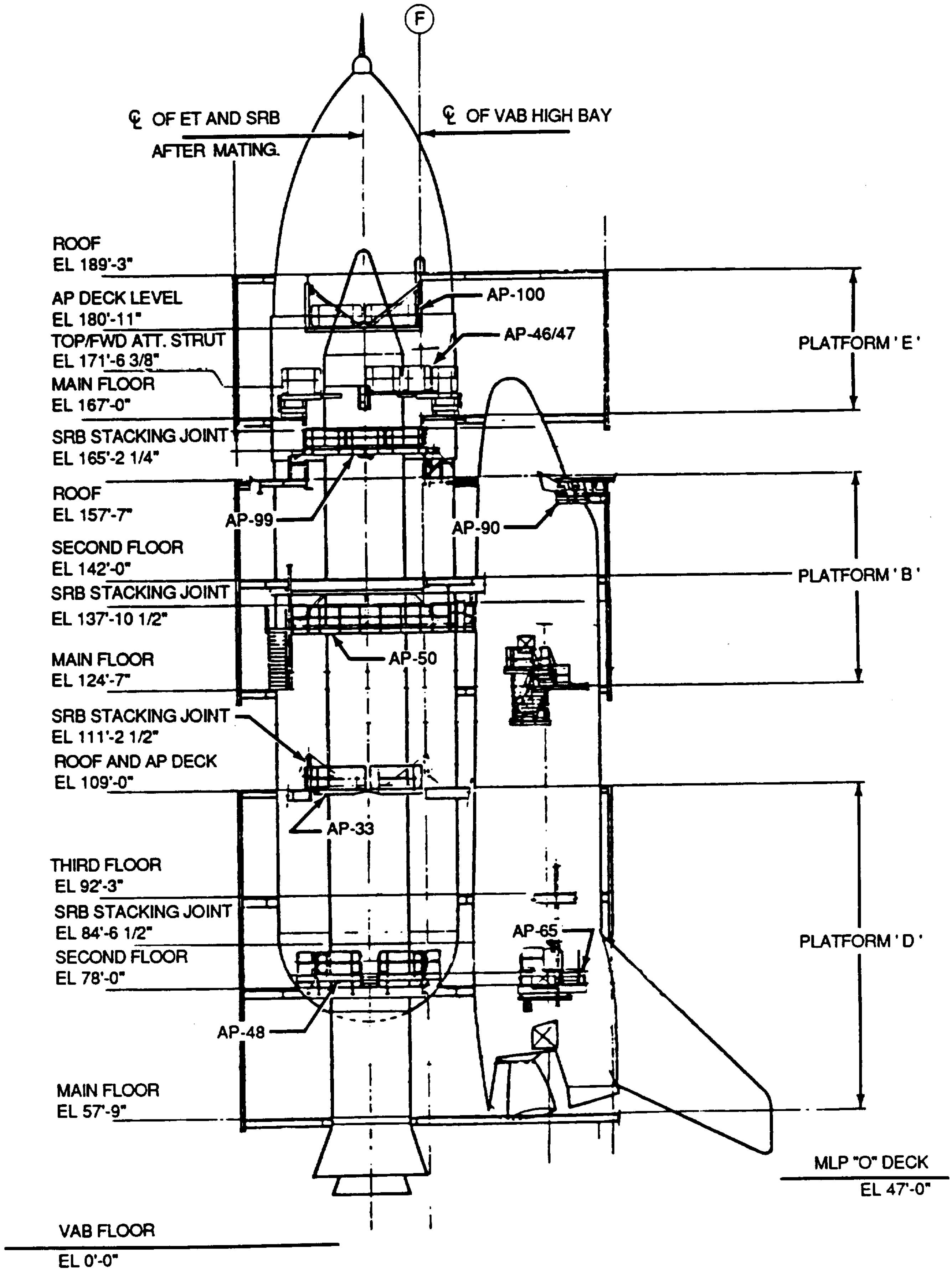


Figure 3.2.1.1. Existing Vehicle Access Platforms and Key Elevation (High Bay 3).

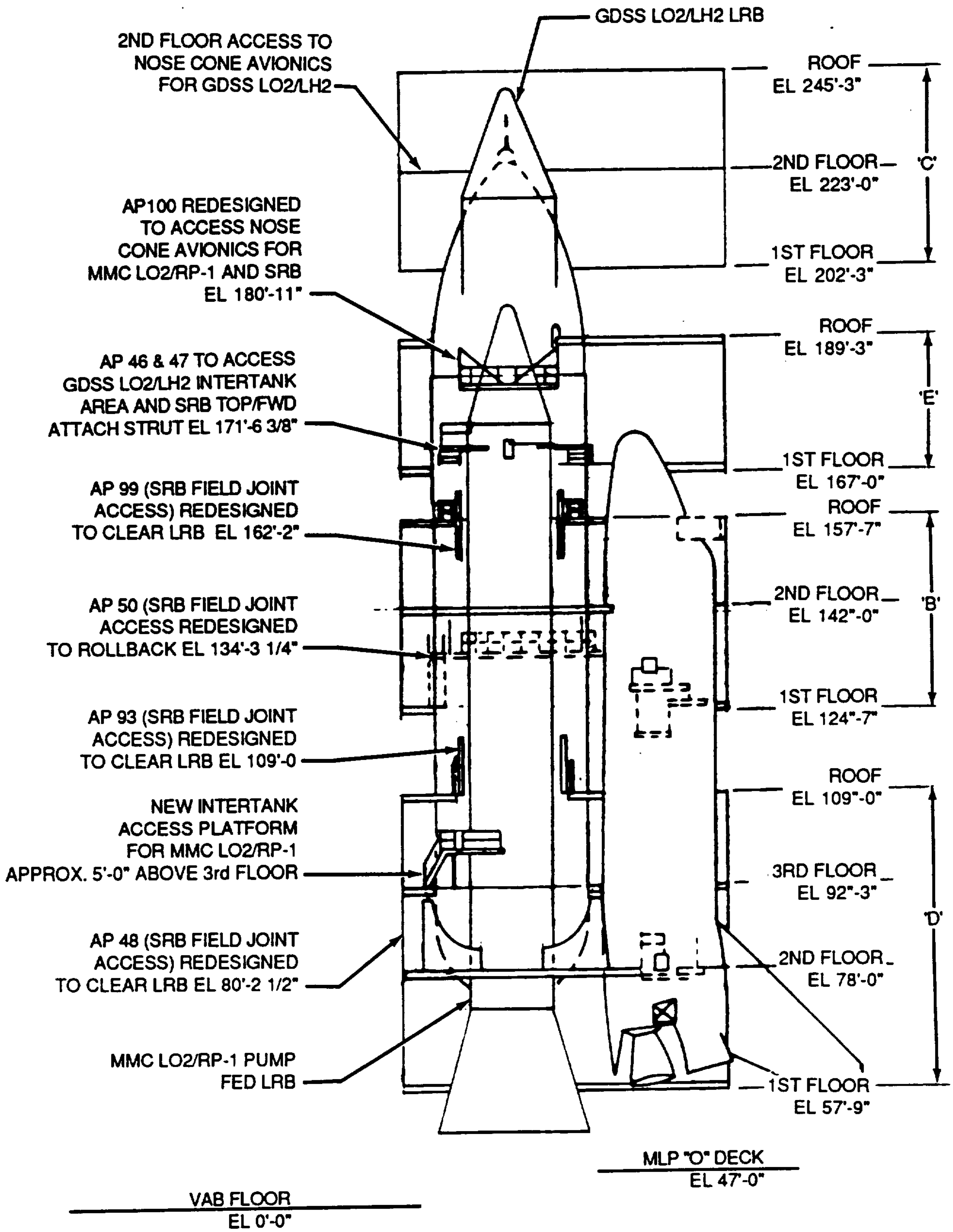


Figure 3.2.1.2-1 New LRB Access Elevation (High Bay 3).

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LRB ACCESS REQUIREMENTS							
	MMC		GDSS				
	LO2/RP-1 PUMP-FED	LO2/RP-1 PRESS-FED	LO2/RP-1 PUMP-FED	LO2/RP-1 PRESS-FED	LO2/LH2	LO2/CH4	LO2/LH2 FATBIRD
BOOSTER DIAMETER	15.3'	16.2'	14.1'	15.0'	16.2'	15.0'	17.7'
HEIGHT	150.9'	162.7'	148.8'	195.7'	190.5'	150.5'	169.5'
ENGINE LEVEL ACCESS (REF: MLP '0' DECK)	MLP '0'	MLP '0'	MLP '0'	MLP '0'	MLP '0'	MLP '0'	MLP '0'
INTERTANK AREA (EL. ABOVE MLP '0' DECK)	56.7'	60.3'	59.2'	81.6'	125.3'	65.4'	111.8'
FWD AREA (EL. ABOVE MLP '0' DECK)	126.0'	130.7'	126.8'	173.3'	165.4'	126.7'	144.0'
℄ LRB TO ℄ ET	22'-5"	22'-9-1/2"	21'-10"	22'-3-1/2"	22'-10-1/2"	22'-3-1/2"	23'-7-1/2"

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Figure 3.2.1.2-2. LRB Access Requirements.

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3.2.1.3 Impacts

Modifications to the existing extensible platforms D, B, E, and C, and the auxiliary platforms would be required.

Extensible Platform D The 1st, 2nd, and 3rd floors and the roof structure would require extensive modifications to contour the larger diameter LRBs. (See Figures 3.2.1.3-1 thru 3.2.1.3-5.) Auxiliary platforms AP48 and AP93 would require redesigning to clear the larger diameter LRB in the retract position. The MMC LO2/RP-1 pump-fed booster intertank area requires designing a new auxiliary platform above the 3rd floor.

The structural modifications to the existing floor levels to contour the larger diameter LRB would require a complete structural analysis study. The existing design of the SRB field joint platform AP48 must be a modified flip-up platform when it is stowed so that it would clear the larger LRBs. The existing design of the SRB field joint platform AP93 flip-up hinge while in the stowed position must be relocated to clear the larger LRBs. The MMC LO2/RP-1 pump-fed intertank area would require a new cantilever stair access platform design. Refer to Figure 3.2.1.2-1.

Extensible Platform B - The 1st floor, 2nd floor, and roof structure would require extensive modifications to contour the larger diameter LRBs. See Figure 3.2.1.3-6 and 3.2.1.3-7. Auxiliary platforms AP50 and AP99 would require redesigning to clear the larger diameter LRB in the retract position. The structural modifications to the existing floor levels to contour the larger diameter LRBs would require a complete structural analysis study. The SRB field joint access auxiliary platform AP50 would require designing so that it could serve as a roll-out type platform supported under the 2nd floor. The SRB field joint access auxiliary platform AP99 existing design of rotating in a down position would have to be modified to clear the larger LRB in the retract position. Refer to Figure 3.2.1.2-1.

Extensible Platform E The 1st floor and roof structure would require extensive modification to contour the larger diameter LRB. See Figure 3.2.1.3-8, 3.2.1.3-9, and 3.2.1.3-10. Auxiliary platforms AP46 and AP47 would need to be redesigned to allow access to the SRB/LRB attach strut and for access to the GDSS LO2/LH2 intertank area. Also, AP100 would need redesigning to allow access to the SRB Nose Cone area and the MMC LO2/RP-1 Pump-Fed Nose Cone area. The structural modifications to the existing floor levels to contour the larger diameter LRBs would require a complete structural analysis study. The SRB top/forward attach point access

EXTENSIBLE PLATFORM 'D' MODIFICATIONS							
LEVELS & AUXILIARY PLATFORM	TYPE OF BOOSTER						
	MMC LO2/RP-1 PUMP-FED	MMC LO2/RP-1 PRESS-FED	GDSS LO2/RP-1 PUMP-FED	GDSS LO2/RP-1 PRESS-FED	GDSS LO2/LH2	GDSS LO2/CH4	GDSS LO2/LH2 FATBIRD
1st FLOOR (MAIN FLOOR)	AS SHOWN ON FIG. 3.2.1.3-2.	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS	AS SHOWN ON FIG. 3.2.1.3-2.	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS
2ND FLOOR	AS SHOWN ON FIG. 3.2.1.3-3.	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS	AS SHOWN ON FIG. 3.2.1.3-3.	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS
AP 48	AS SHOWN ON FIG. 3.2.1.2-1.	REDESIGN FLIP-UP PLATFORM WITH DIVING BOARD EXTENSION	REDESIGN FLIP-UP PLATFORM WITH DIVING BOARD EXTENSION	REDESIGN FLIP-UP PLATFORM WITH DIVING BOARD EXTENSION	AS SHOWN ON FIG. 3.2.1.2-1.	REDESIGN FLIP-UP PLATFORM WITH DIVING BOARD EXTENSION	REDESIGN FLIP-UP PLATFORM WITH DIVING BOARD EXTENSION
3RD FLOOR	AS SHOWN ON FIG. 3.2.1.3-4.	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS	RECONFIGURE EXT STRUCT MOD DESIGN ROLLOUT PLATF FOR INTERTANK ACCESS	RECONFIGURE EXTENSIVE STRUCTURAL ACCESS	AS SHOWN ON FIG. 3.2.1.3-4.	RECONFIGURE EXTENSIVE STRUCTURAL ACCESS	RECONFIGURE EXTENSIVE STRUCTURAL ACCESS
ROOF	AS SHOWN ON FIG. 3.2.1.3-5.	RECONFIGURE EXT STRUCT MOD DESIGN ROLLOUT PLATF FOR INTERTANK ACCESS	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS	AS SHOWN ON FIG. 3.2.1.3-5.	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS	RECONFIGURE EXT STRUCT MOD DESIGN ROLLOUT PLATF FOR INTERTANK ACCESS
AP 93	AS SHOWN ON FIG. 3.2.1.2-1.	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS	AS SHOWN ON FIG. 3.2.1.2-1.	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS

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Figure 3.2.1.3-1. Extensible Platform "D" Modifications.

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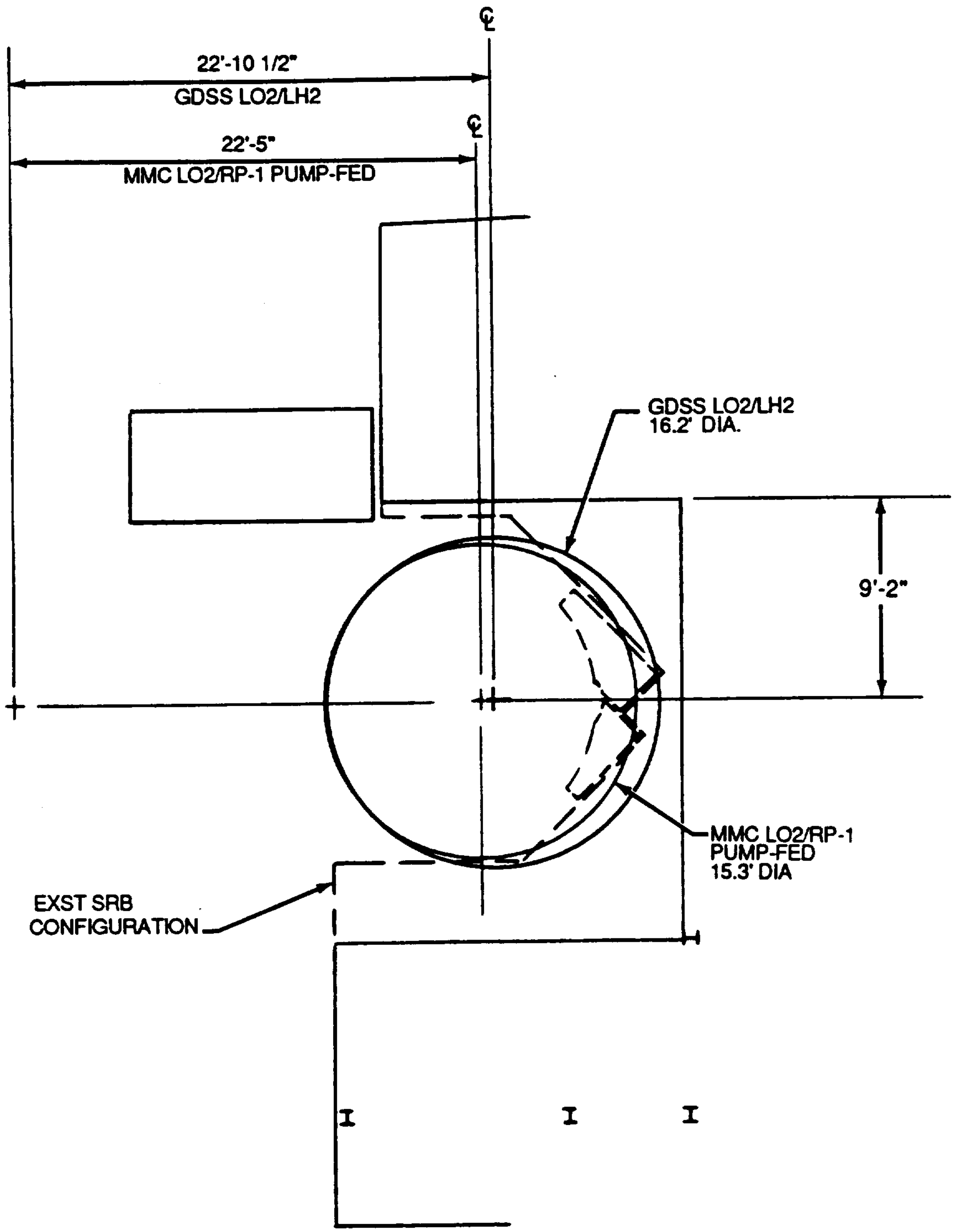


Figure 3.2.1.3-2. Main Floor - Platform 'D' Interferences.

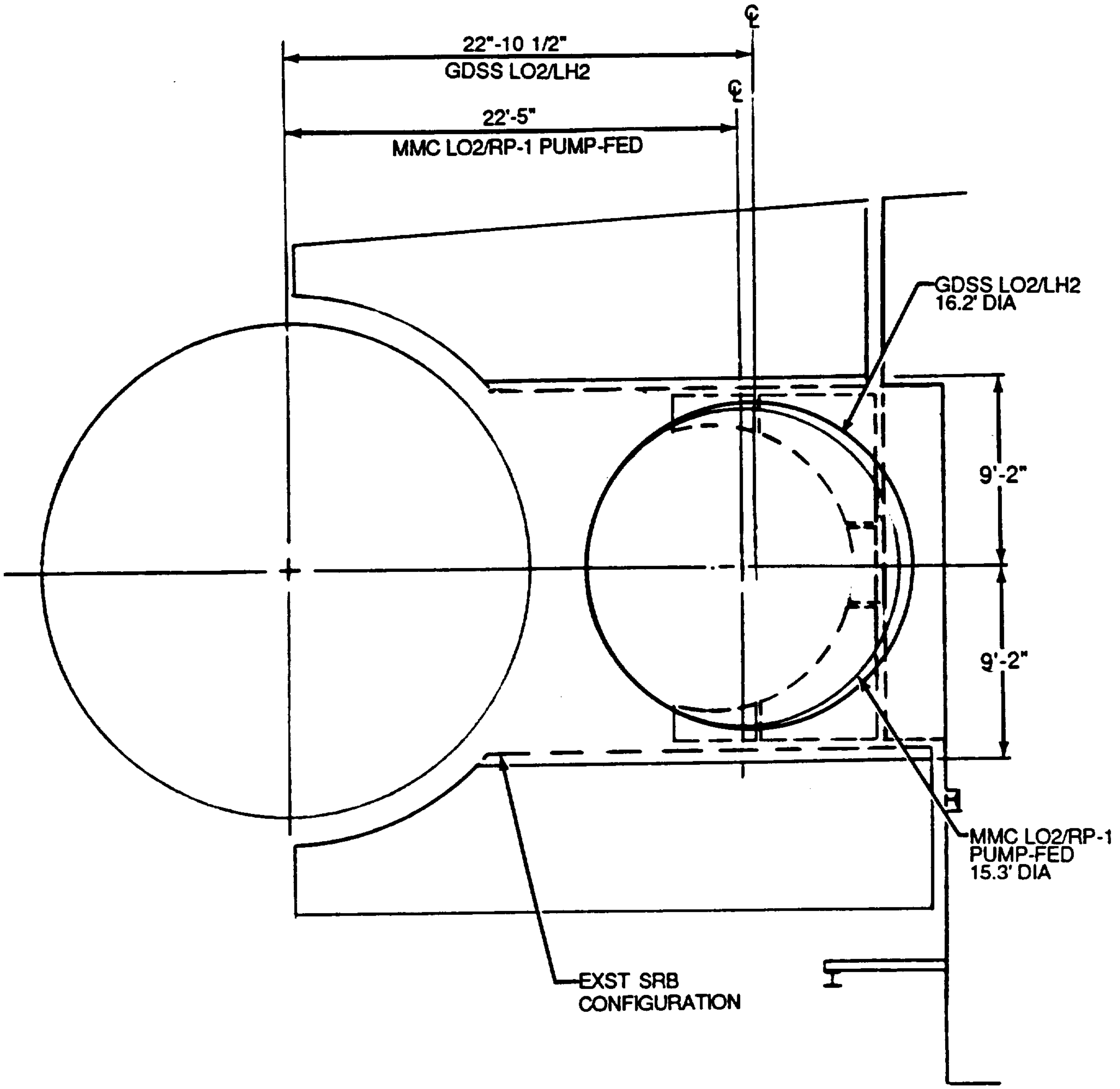


Figure 3.2.1.3-3. 2nd Floor - Platform 'D' Interferences.

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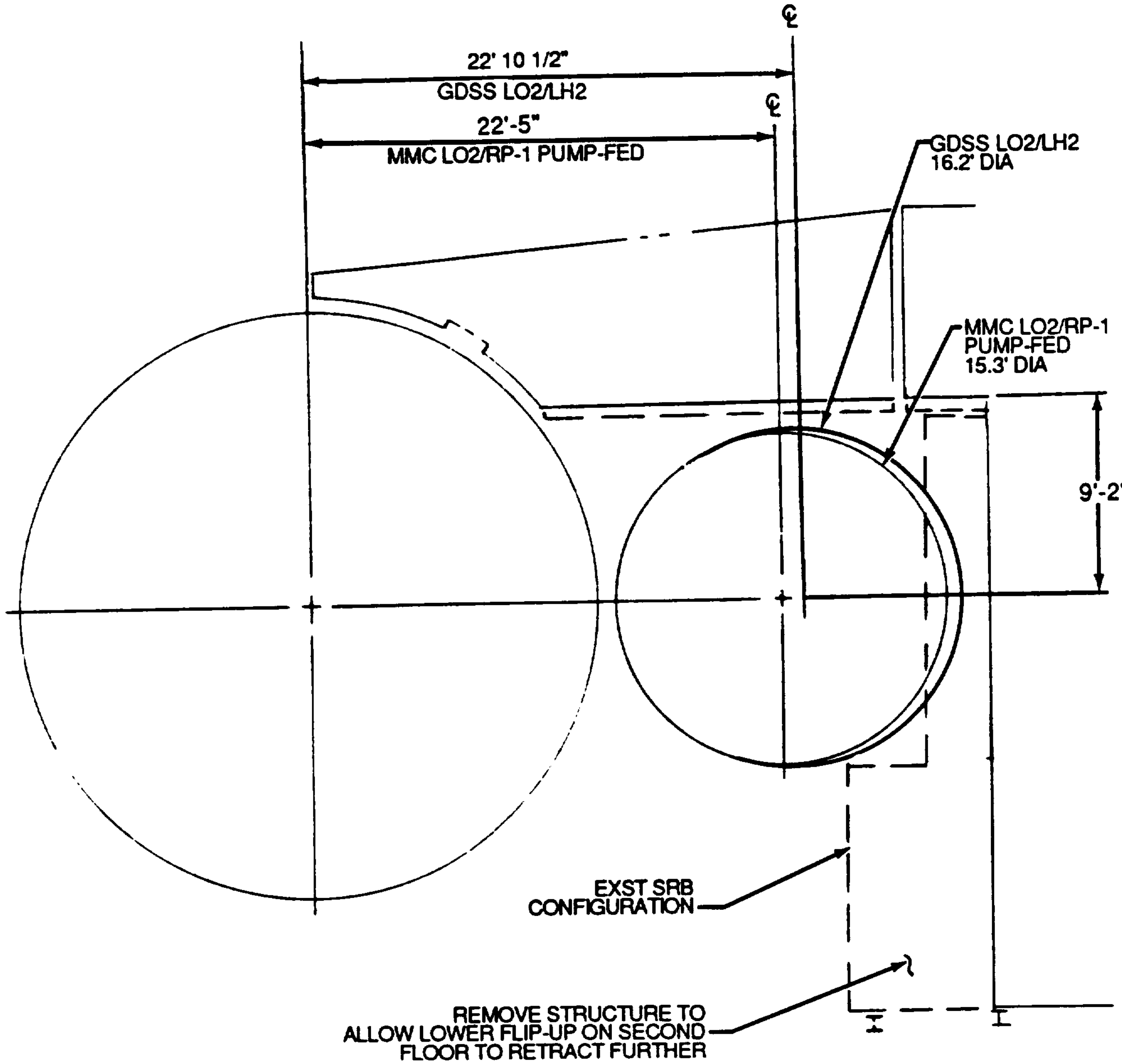


Figure 3.2.1.3-4. 3rd Floor - Platform 'D' Interferences.

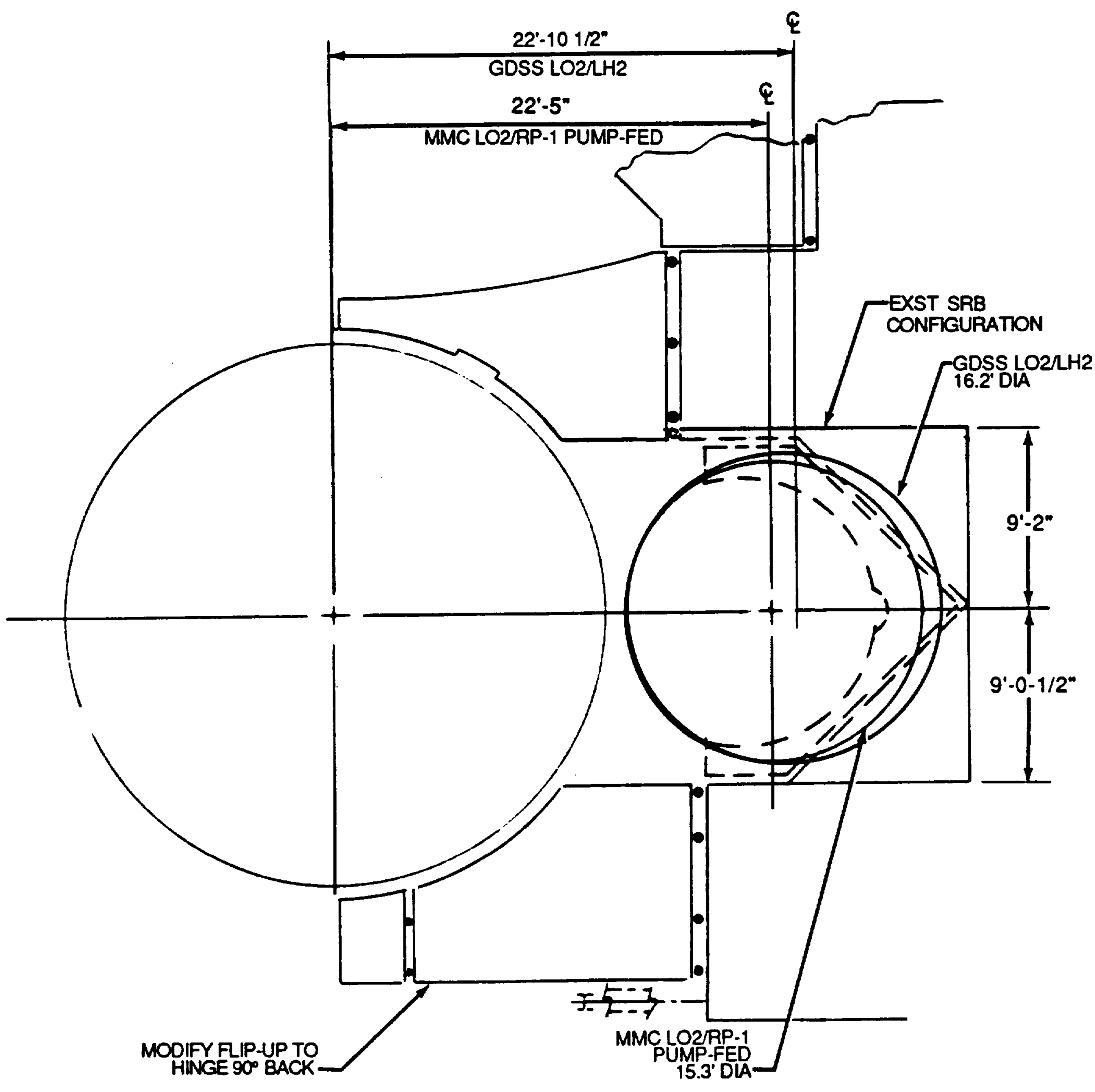


Figure 3.2.1.3-5. Roof - Ext. Work Platform 'D' Interferences.

EXTENSIBLE PLATFORM 'B' MODIFICATIONS							
	TYPE OF BOOSTER						
LEVELS & AUXILIARY PLATFORM	MMC LO2/RP-1 PUMP-FED	MMC LO2/RP-1 PRESS-FED	GDSS LO2/RP-1 PUMP-FED	GDSS LO2/RP-1 PRESS-FED	GDSS LO2/LH2	GDSS LO2/CH4	GDSS LO2/LH2 FATBIRD
1st FLOOR MAIN FLOOR	AS SHOWN ON FIG 3.2.1.3-7.	RECONFIGURE EXT STRUCT MOD PORTABLE INTERTANK ACCESS PLATF	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS	RECONFIGURE EXT STRUCT MOD REDESIGN ROLLOUT INTERTANK ACCESS PLATF.	AS SHOWN ON FIG 3.2.1.3-7.	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS
AP 50	AS SHOWN ON FIG 3.2.1.2-1.	REDESIGNED TO ROLLOUT UNDER THE SECOND FLOOR	REDESIGNED TO ROLLOUT UNDER THE SECOND FLOOR	REDESIGNED TO ROLLOUT UNDER THE SECOND FLOOR	AS SHOWN ON FIG 3.2.1.2-1.	REDESIGNED TO ROLLOUT UNDER THE SECOND FLOOR	REDESIGNED TO ROLLOUT UNDER THE SECOND FLOOR
2ND FLOOR	AS SHOWN ON FIG 3.2.1.3-7.	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS	AS SHOWN ON FIG 3.2.1.3-7.	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS
ROOF	AS SHOWN ON FIG 3.2.1.3-7.	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS	AS SHOWN ON FIG 3.2.1.3-7.	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS
AP 99	AS SHOWN ON FIG 3.2.1.2-1.	MODIFY THE EXST PLATFORM TO ROTATE IN THE DOWN POSITION TO CLEAR LRB	MODIFY THE EXST PLATFORM TO ROTATE IN THE DOWN POSITION TO CLEAR LRB	MODIFY THE EXST PLATFORM TO ROTATE IN THE DOWN POSITION TO CLEAR LRB	AS SHOWN ON FIG 3.2.1.2-1.	MODIFY THE EXST PLATFORM TO ROTATE IN THE DOWN POSITION TO CLEAR LRB	MODIFY THE EXST PLATFORM TO ROTATE IN THE DOWN POSITION TO CLEAR LRB

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Figure 3.2.1.3-6. Extensive Platform 'B' Modifications.

3-3.2 11/11 2:30p

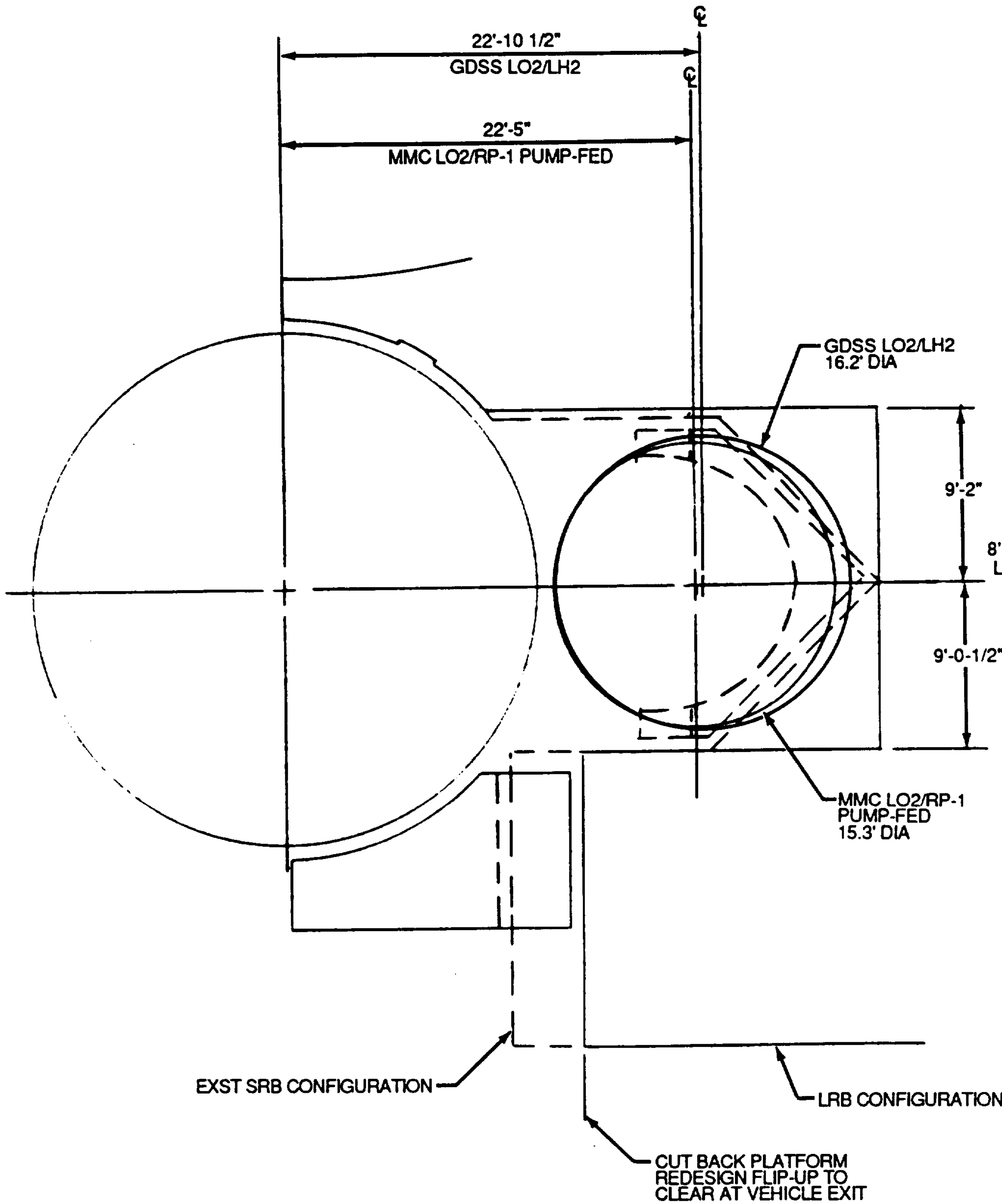


Figure 3.2.1.3-7. Main Floor - Platform 'B' Interferences
2nd Floor & Roof (Similar)

	EXTENSIBLE PLATFORM "E" MODIFICATIONS						
	TYPE OF BOOSTER						
LEVELS & AUXILIARY PLATFORM	MMC LO2/RP-1 PUMP-FED	MMC LO2/RP-1 PRESS-FED	GDSS LO2/RP-1 PUMP-FED	GDSS LO2/RP-1 PRESS-FED	GDSS LO2/LH2	GDSS LO2/CH4	GDSS LO2/LH2 FATBIRD
1st FLOOR (MAIN FLOOR)	AS SHOWN ON FIG.3.2.1.3-9	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS	AS SHOWN ON FIG.3.2.1.3-9	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS
AP 46 & 47	AS SHOWN ON FIG.3.2.1.2-1.	MODIFY ROLLING PLATFORM WITH DIVING BOARDS TO REACH ATTACH POINT	MODIFY ROLLING PLATFORM WITH DIVING BOARDS TO REACH ATTACH POINT	MODIFY ROLLING PLATFORM WITH DIVING BOARDS TO REACH ATTACH POINT	MODIFY ROLLING PLATFORM WITH DIVING BOARDS TO REACH ATTACH POINT	MODIFY ROLLING PLATFORM WITH DIVING BOARDS TO REACH ATTACH POINT	MODIFY ROLLING PLATFORM WITH DIVING BOARDS TO REACH ATTACH POINT
ROOF	AS SHOWN ON FIG.3.2.1.3-10.	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS	AS SHOWN ON FIG.3.2.1.3-10.	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS	RECONFIGURE EXTENSIVE STRUCTURAL MODIFICATIONS
AP 100	AS SHOWN ON FIG.3.2.1.2-1.	REDESIGN TO CONTOUR LRB W/ EXTENDABLE FILLER PLATES FOR SRB NOSE CONE ACCESS	REDESIGN TO CONTOUR LRB W/ EXTENDABLE FILLER PLATES FOR SRB NOSE CONE ACCESS	REDESIGN TO CONTOUR LRB W/ EXTENDABLE FILLER PLATES FOR SRB NOSE CONE ACCESS	AS SHOWN ON FIG.3.2.1.2-1.	REDESIGN TO CONTOUR LRB W/ EXTENDABLE FILLER PLATES FOR SRB NOSE CONE ACCESS	REDESIGN TO CONTOUR LRB W/ EXTENDABLE FILLER PLATES FOR SRB NOSE CONE ACCESS

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Figure 3.2.1.3-8. Extensible Platform "E" Modifications.

3-3.2 11/11 2:30p

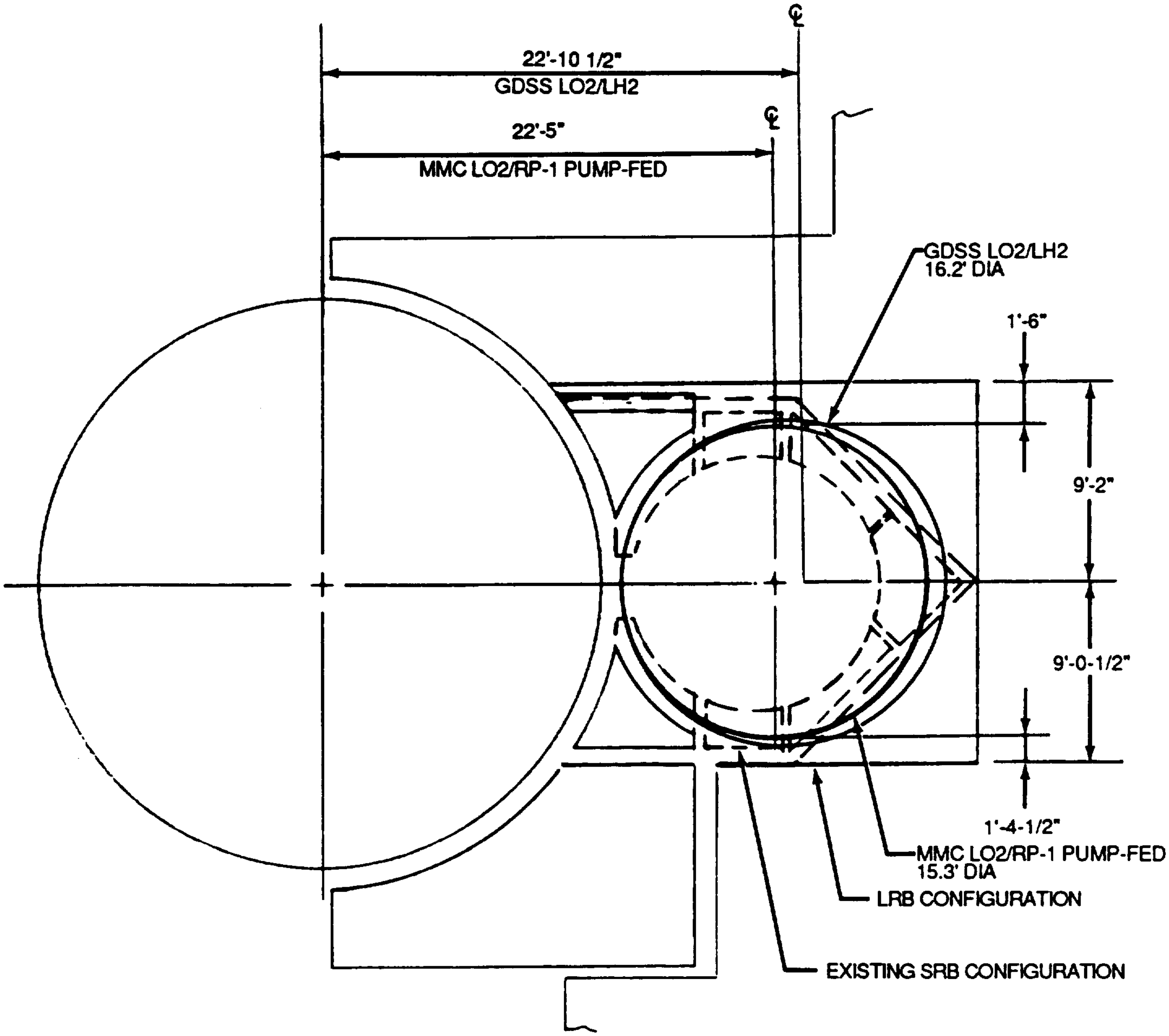


Figure 3.2.1.3-9. Main Floor - Platform 'E' Interferences.

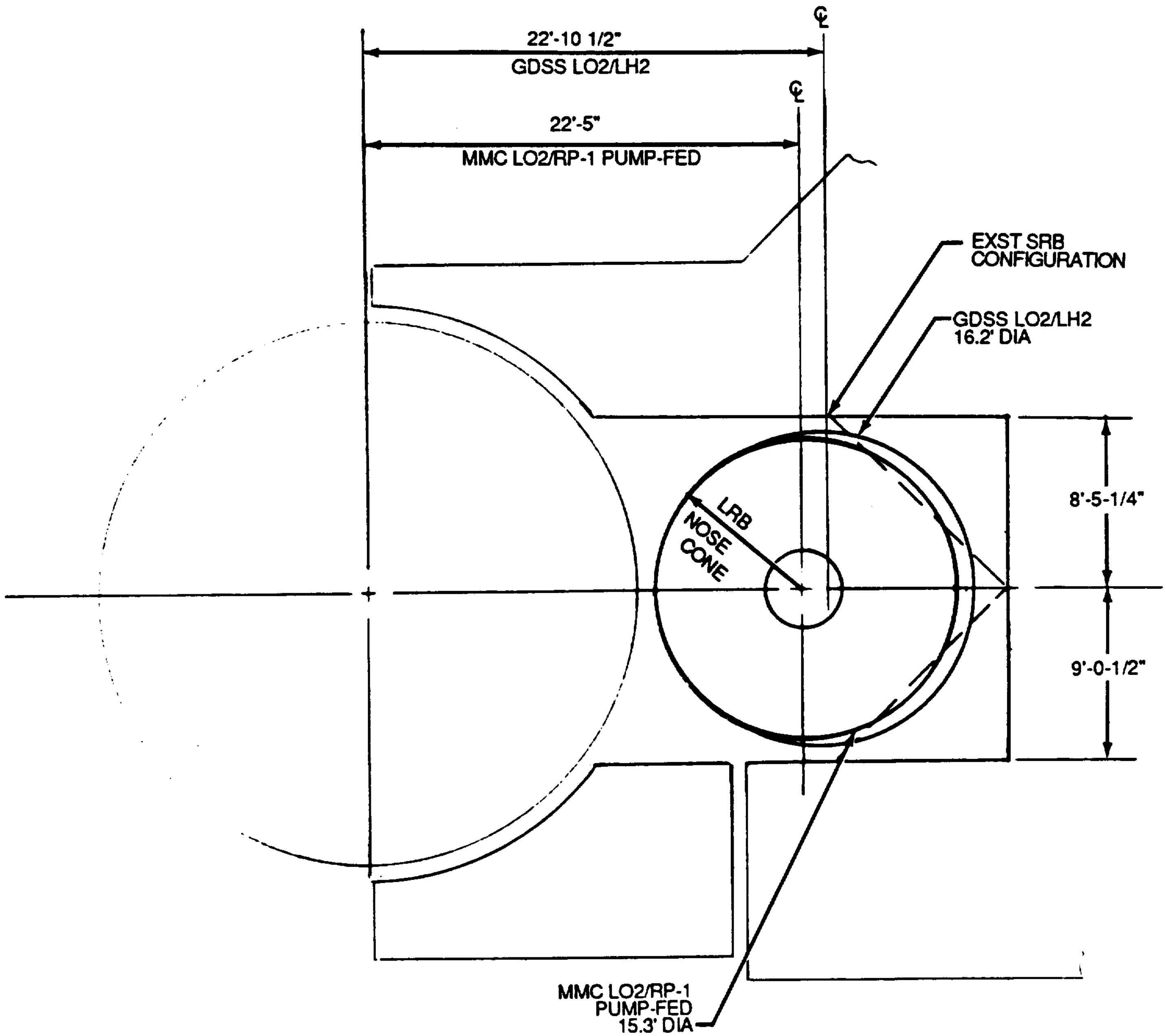


Figure 3.2.1.3-10. Roof - Platform 'E' Interferences.

auxiliary platforms AP46 and AP47 rolling platform with cantilever diving board would require modification to access the LO2/LH2 intertank area. The SRB Nose Cone access auxiliary platform AP100 would need redesigning to contour the larger diameter LRBs for Nose Cone access and extendible filler plates to contour the SRB Nose Cone. Refer to Figure 3.2.1.2-1.

Extensible Platform C - The 1st and 2nd floor structure would require extensive modification to contour the GDSS LO2/LH2 LRB. (See Figures 3.2.1.3-11, 3.2.1.3-12, and 3.2.1.3-13. The 2nd floor provides direct access to the SRB Nose Cone. The structural modifications to the existing 1st and 2nd floor levels to contour the larger diameter LRB would require a complete structural analysis. A major concern is that this extensible platform is not as wide as extensible platforms D, B, and E, and the larger diameter will affect existing column members.

3.2.1.4 Conclusions

The structural integrity of the existing extensible platforms will be affected by the modifications required to clear the envelope of the LRB. Each floor level needs to be analyzed on a case-by-case basis. The LRB concept chosen will determine the direct impact on the structural members. All existing SRB access requirements should be reviewed to ensure that the new modifications for LRB have not eliminated the ability to perform the process operation tasks.

As stated in the groundrules, the modification of High Bay 3 to support both LRBs and SRBs should not commence until High Bay 4 is operational for processing with LRBs/SSVs. This scenario would have the least impact on the proposed flight schedule, since SRB flights should be fewer than seven and would be supported by High Bay 1 only.

3.2.1.5 References

HB1 Drawing 79K09164, High Bay 1, Shuttle Modifications

HB3 Drawing 79K05424, Vehicle Assembly Building Modifications, High Bay 3

Martin Marietta Performance Review: Liquid Rocket Booster (LRB) for the Space Transportation System (STS) System Study, June 1988

Performance Summary Parameters Configurations/Dimensions, June 1988

Lockheed Space Operations Company Liquid Rocket Booster Integration First Progress Review, July 1988

ICD-2-0A002, Rev. H Shuttle System/Launch Platform Stacking and VAB Servicing

EXTENSIBLE PLATFORM 'C' MODIFICATIONS							
LEVELS & AUXILLARY PLATFORM	TYPE OF BOOSTER						
	MMC LO2/RP1 PUMP FED	MMC LO2/RP1 PRESS FED	GDSS LO2/RP1 PUMP FED	GDSS LO2/RP1 PRESS FED	GDSS LO2/LH2	GDSS LO2/CH4	GDSS LO2/LH2 FATBIRD
1st FLOOR	NO CHANGE	RECONFIGURE EXTENSIVE MODIFICATION ACCESS TO NOSE CONE	NO CHANGE	RECONFIGURE EXTENSIVE STRUCT	AS SHOWN ON FIG 3.2.1.3-12	NO CHANGE	RECONFIGURE EXTENSIVE MODIFICATION ACCESS TO NOSE CONE
2ND FLOOR	NO CHANGE	NO CHANGE	NO CHANGE	RECONFIGURE EXT STRUCT MOD PORTABLE WORK STANDS TO ACCESS NOSE CONE	AS SHOWN ON FIG 3.2.1.3-13	NO CHANGE	NO CHANGE
ROOF	NO CHANGE	NO CHANGE	NO CHANGE	NO CHANGE	NO CHANGE	NO CHANGE	NO CHANGE

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Figure 3.2.1.3-11. Extensible Platform 'C' Modifications

3-3.2 11/16 8:00a

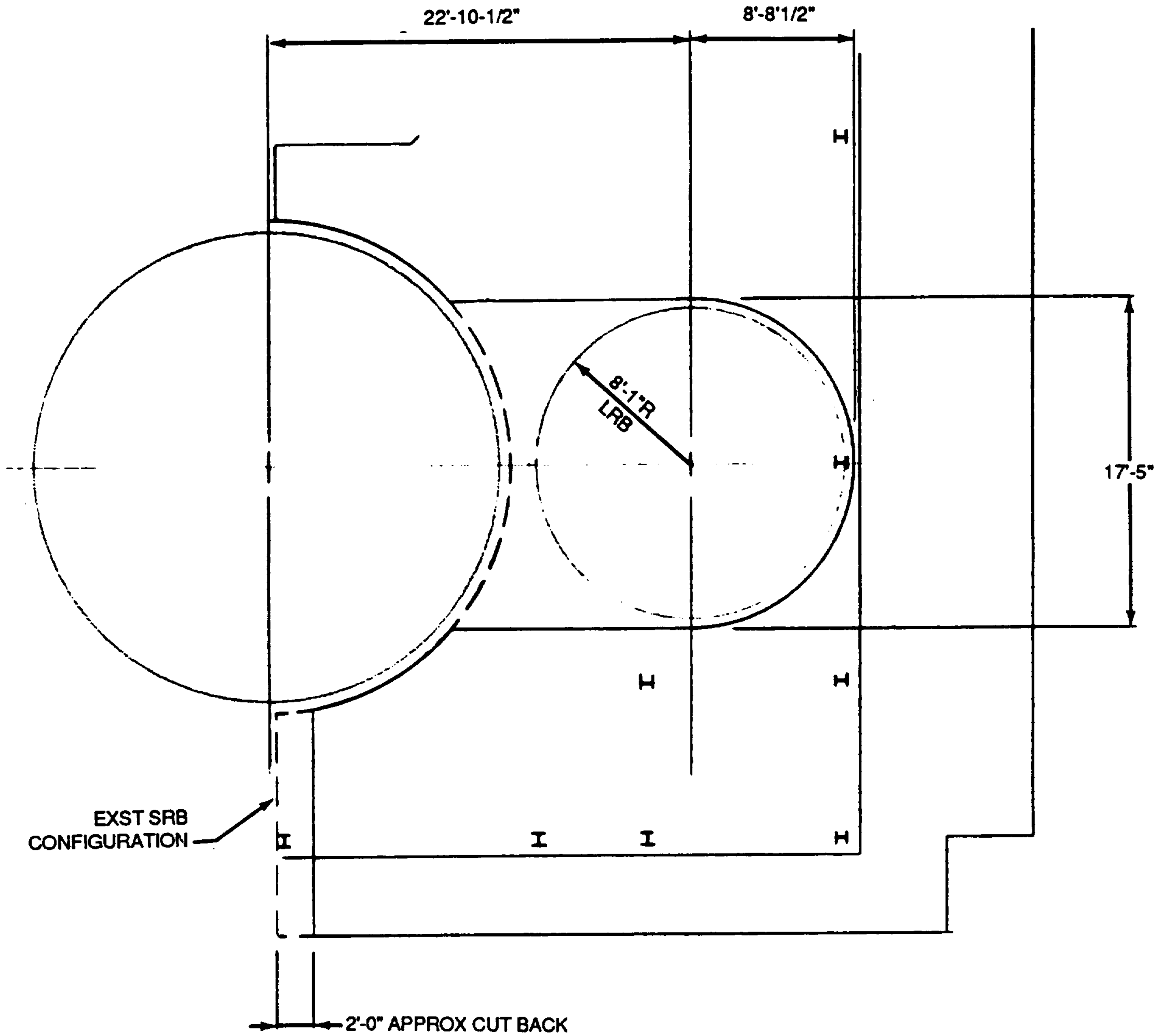


Figure 3 1.3-12. 1st Floor - Platform 'C'.

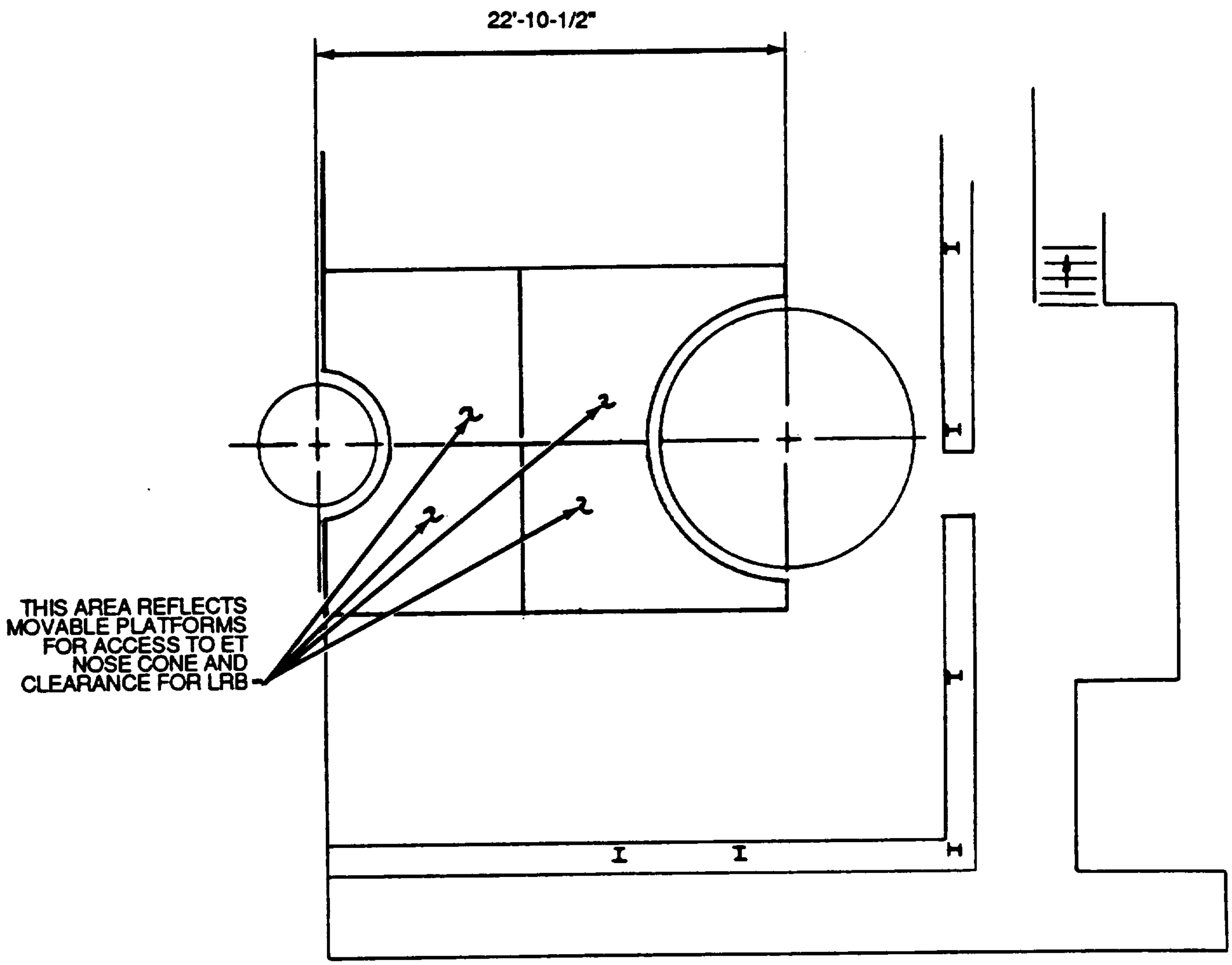


Figure 3.2.1.3-13. 2nd Floor - Platform 'C'.

3.2.2 VAB High Bay 4 Access Requirements

To meet a launch rate of three LRBs in 1996 and still maintain an SRB launch capability in High Bay 1 and High Bay 3, it would be necessary to convert High Bay 4 into an LRB stacking and checkout cell. Converting High Bay 4 would have little or no effect on existing Shuttle processing in High Bays 1 and 3.

3.2.2.1 Existing Condition

At present, High Bay 4 is used as a storage and checkout cell for the ET and has a capability of providing buildup stands for the SRB segments. No platforms are available to access the Orbiter, LRBs, and ETs; new platforms would have to be built.

3.2.2.2 Demolition Requirements

To convert High Bay 4 into an LRB stacking facility, the present ET checkout function would be required to be relocated to the new ET/LRB Horizontal Processing Facility. The SRB buildup stands would be dismantled and relocated to High Bay 2.

Out of four MLP pedestals, three have been dismantled and stored in the MLP park- site area. These are not structurally sound after being in open storage for a number of years. Thus, new pedestals would be required.

3.2.2.3 Access Requirements

Orbiter

The Orbiter has six main areas that require personnel access. They include the aft fuselage access door, aft and forward attach points of the ET/Orbiter, mid-fuselage and preflight umbilicals, star tracker door, and crew cabin access door. New platforms designed to fit around the LRBs for these areas will be required. Figure 3.2.2.3-1 shows the relationship of the platforms to the Orbiter. Figure 3.2.2.3-2 presents the concept for the crew cabin access room. Figure 3.2.2.3-3 lists the present levels and platforms in High Bays 1 and 3 that would be required for High Bay 4.

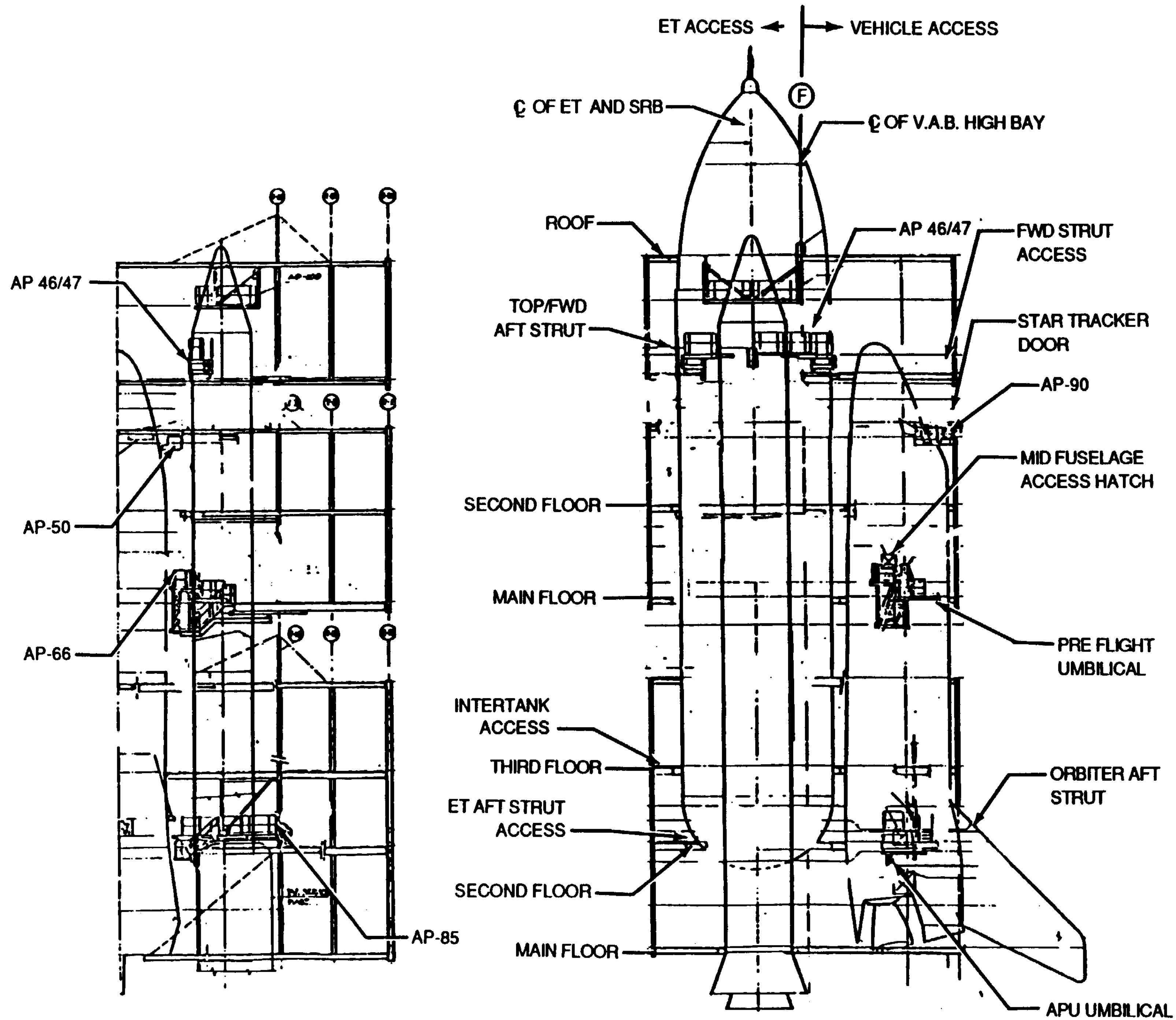


Figure 3.2.2.3-1 Orbiter/ET Access Platform (High Bay 4)

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3-3.2 11/8 1:00p

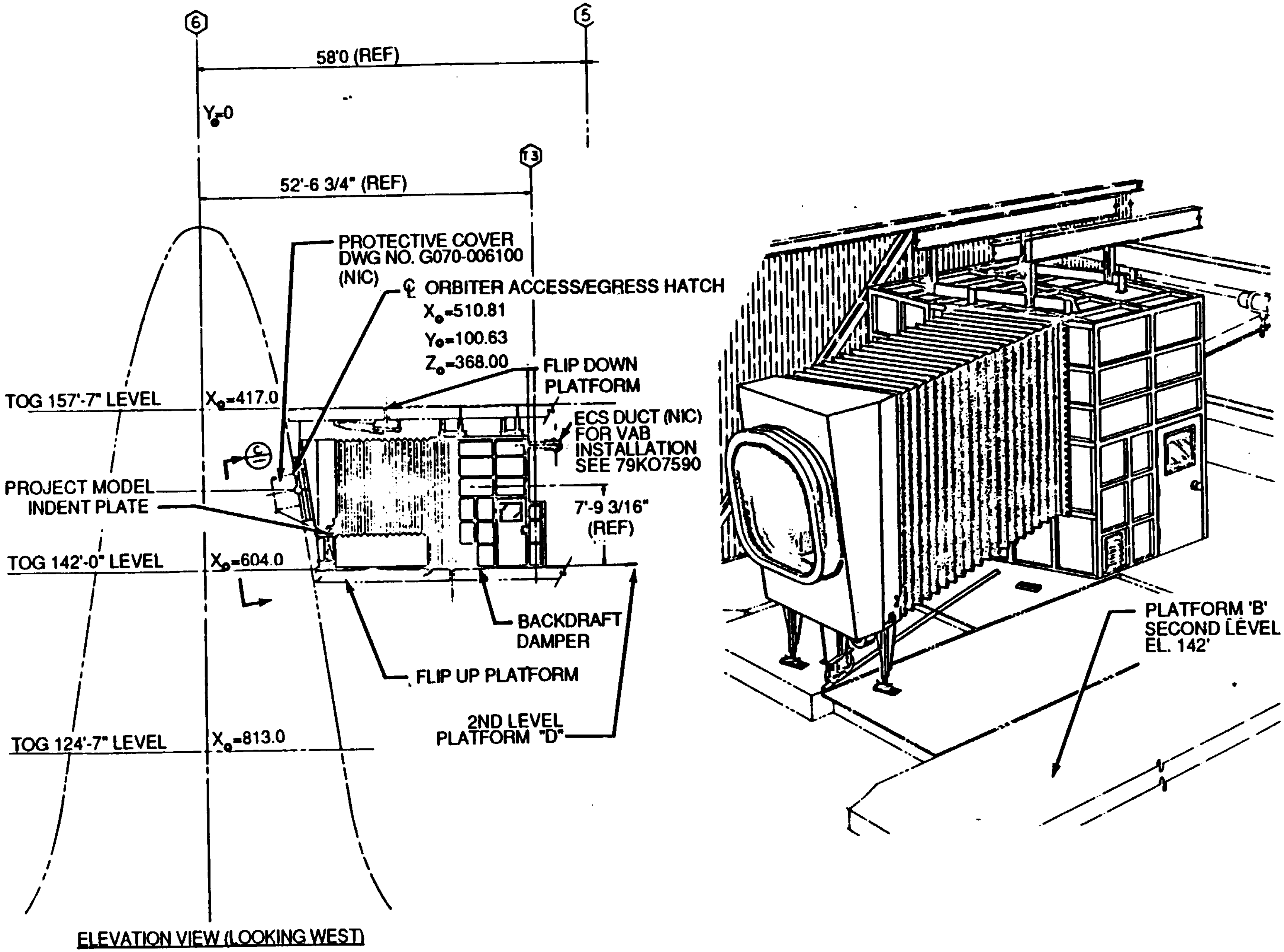


Figure 3.2.2.3-2. Orbiter Access RM Vehicle Access (High Bay 4).

81005-01BD

3-3.2 10/28 8:00a

ITEMS (ACCESS REQUIREMENTS)	ORBITER	EXTERNAL TANK	ACCESS LEVEL FROM HB 4
AFT FUSELAGE ACCESS DOOR	✓	—	2ND FLOOR PLATFORM LEVEL 'D' + AP 65
AFT ATTACH POINT	✓	✓	2ND FLOOR PLATFORM LEVEL 'D' + AP 65
MID FUSELAGE AND PREFLIGHT UMBILICALS	✓	—	MAIN FLOOR PLATFORM LEVEL 'B' + AP 66
INTERTANK ACCESS	—	✓	MAIN FLOOR PLATFORM LEVEL 'E'
ORBITER ACCESS ROOM + STAR TRACKER DOOR	✓	—	ROOF PLATFORM LEVEL 'B' + AP 90
FWD ATTACH POINT	✓	✓	1ST FLOOR PLATFORM LEVEL 'E'
ENGINE SERVICE PLATFORM	✓	—	USE EXISTING ESP

Figure 3.2.2.3-3. Orbiter and ET Access Requirements (High Bay 4).

External Tank

The ET has three main areas that require personnel access. They include the aft and forward attach points with the Orbiter and the intertank area. The new platforms required for these areas must be designed to fit around the LRB. Figure 3.2.2.3-1 shows the relationship of the platforms to the ET. Figure 3.2.2.3-3 lists the present levels and platforms in High Bays 1 and 3 that would be required in High Bay 4.

LRB

Proposed access platforms for the LRB are located on the MLP deck (for engine service), LRB intertank area, and nose cone area as shown in Figure 3.2.2.3-4. Figure 3.2.2.3-5 lists the LRB access requirements. Figure 3.2.2.3-6 shows the relationship of the MMC RP1/LOX pump-fed configuration with the High Bays 1 and 3 platform elevation design. The intertank area is close to Platform E, and the nose cone is close to Platform D (3rd floor). Figure 3.2.2.3-6 lists the High Bay platform designs which are applicable to LRBs. Engine access platform is discussed in paragraph 3.3.3.

3.2.2.4 References

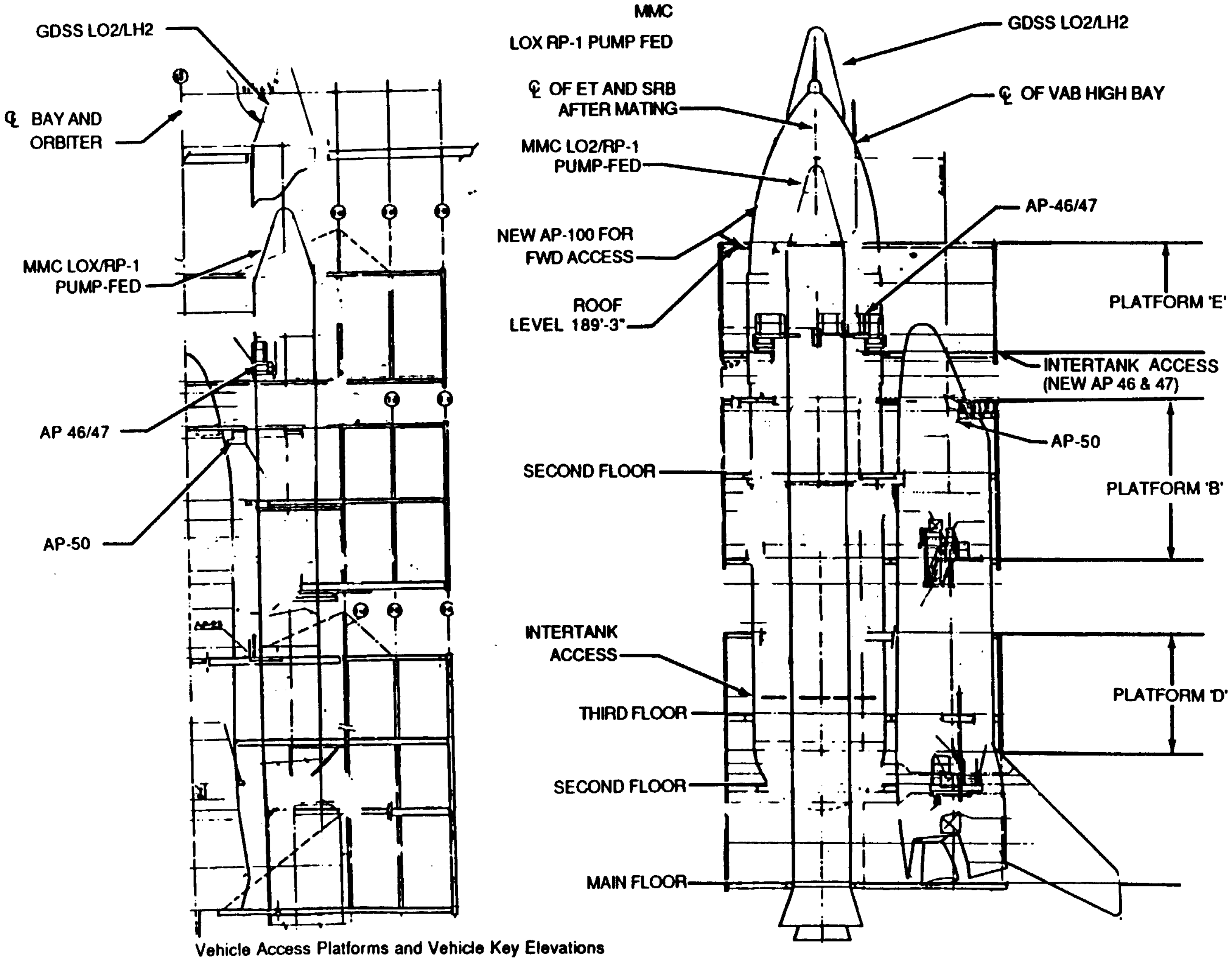
VAB High Bay 1 79K09164
VAB High Bay 3 79K05424
ICD-2-0A001, Rev. H Shuttle System/Launch Platform Stacking and VAB Servicing

3.2.3 VAB High Bay LRB/SSV Rollout Clearances

An evaluation study was conducted on VAB High Bay 3 platform and VAB High Bays 3 and 4 doors for LRB/ET/Orbiter exit from the VAB.

3.2.3.1 Groundrules

The groundrules included the requirement that a minimum of 6 inches clearance distance would be maintained from hard steel to flight hardware not moving; also a requirement: a minimum of 18 inches clearance distance would be maintained from hard steel to flight hardware in motion.



Vehicle Access Platforms and Vehicle Key Elevations

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Figure 3.2.2.3-4. LRB Access Requirements (High Bay 4).

3-3.3 11/16 8:00a

	MMC		GDSS				
	LOX/RP-1 PUMP-FED	LOX/RP-1 PRESSURE-FED	LOX/RP-1 PUMP-FED	LOX/RP-1 PRESSURE-FED	LOX/CH 4	LOX/LH 2	LOX/LH2 FATBIRD
BOOSTER DIAMETER	15.3'	16.2'	14.1'	15.0'	15.0'	16.2'	17.7'
HEIGHT	150.9'	162.7'	148.8'	195.7'	150.5'	190.5'	169.5'
ENGINE LEVEL ACCESS (REF: (MLP "0" DECK)	MLP "0"	MLP "0"	MLP "0"	MLP "0"	MLP "0"	MLP "0"	MLP "0"
INTERTANK ACCESS (EL. ABOVE MLP "0" DECK)	56.7'	60.3'	59.2'	81.6'	65.4'	125.3'	111.8'
FWD ACCESS (EL. ABOVE MLP "0" DECK)	126.0'	130.7'	126.8'	173.3'	126.7'	165.4'	144.0'

Figure 3.2.2.3-5. LRB Access Requirements.

	MMC		GDSS				
	LOX/RP-1 PUMP-FED	LOX/RP-1 PRESSURE-FED	LOX/RP-1 PUMP-FED	LOX/RP-1 PRESSURE-FED	LOX/CH 4	LOX/LH 2	LOX/LH2 FATBIRD
BOOSTER DIAMETER	15.3'	16.2'	14.1'	15.0'	15.0'	16.2'	17.7'
HEIGHT	150.9'	162.7'	148.8'	195.7'	150.1'	191.0'	169.5'
ENGINE LEVEL ACCESS	EL. 47'-0"	EL. 47'-0"	EL. 47'-0"	EL. 47'-0"	EL. 47'-0"	EL. 47'-0"	EL. 47'-0"
INTERTANK ACCESS	PLATFORM 'D' 3RD FLOOR EL. 92'-25"	PLATFORM 'D' 3RD FLOOR EL.92'-25"	PLATFORM 'D' 3RD FLOOR EL. 92'-25"	PLATFORM 'B' MAIN FLOOR EL. 124'-7"	PLATFORM 'D' ROOF EL. 109'-0"	AP-46/47 EL.170"-4"	PLATFORM 'B' 2ND FLOOR EL. 142'-0"
FWD ACCESS	PLATFORM 'E' AP 46/47 EL. 171'-6 3/8"	PLATFORM 'E' AP 46/47 EL. 171'-6 3/8"	PLATFORM 'E' AP 46/47 EL. 171'-6 3/4"	PLATFORM 'C' MAIN FLOOR EL. 202'-3"	PLATFORM 'E' AP 46/47 EL. 171'-6 3/8"	PLATFORM 'C' MAIN FLOOR EL. 202'-3"	PLATFORM 'E' ROOF EL. 189'-3"

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Figure 3.2.2.3-6. LRB Intertank/Forward Access Requirements (High Bay 4).

3-3.2 11/11 2:30p

3.2.3.2 Impacts to High Bay 3 Platforms

Platforms at levels D, B, E, and C in High Bay 3, as shown in Figure 3.2.3.2-1, retract or flip up to make SRB/ET/Orbiter stack clear the High Bay at the time of exit.

Figure 3.2.3.2-1 shows the least and worst LRB impact conditions, along with the existing SRB platform configuration. The MMC LO2/RP-1 pump-fed was selected for the least case and GDSS LO2/LH2 pump-fed is selected as worst case.

A typical plan view for retractable platform infringement for LRB is shown in Figure 3.2.3.2-2.

Platforms affected in the MMC LO2/RP1 pump-fed include:

a. Roof and main platforms of level D
b. Main, second, and roof platforms of level B
c. Main platform of level E

The platforms not affected include:

a. Second and third platforms of level D
b. Roof platform of level E
c. Main, second, and roof platforms of level

The platforms affected in the GDSS LOP2/LH2 pump-fed include:

a. Main and roof platforms of level D
b. Main, second, and roof platforms of level B
c. Main and roof platforms of level E
d. Main and second platforms of level C

Only the roof platform of level C is not affected.

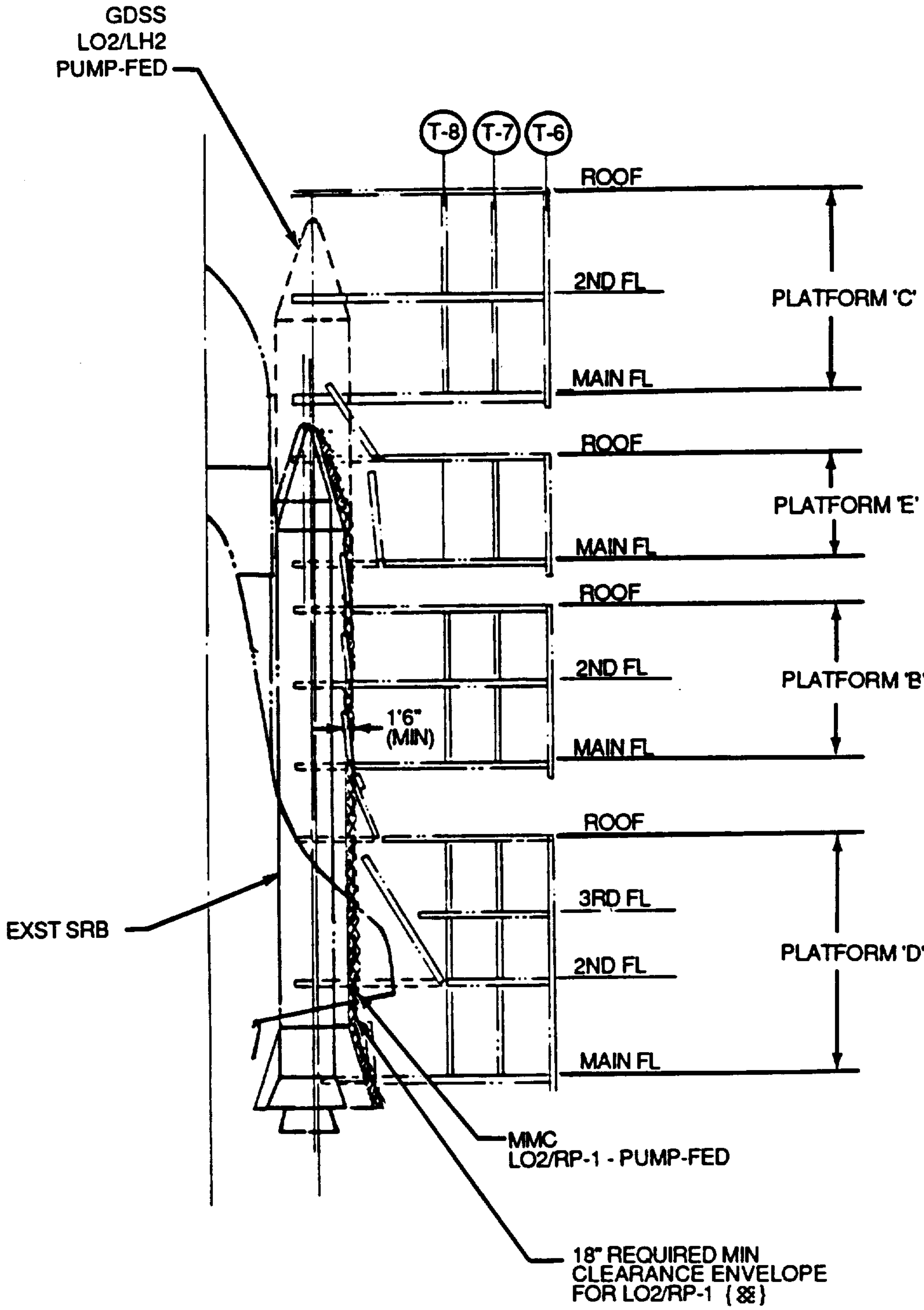


Figure 3.2.3.2-1. Exit Clearance With Extensible Work Platforms Retracted.

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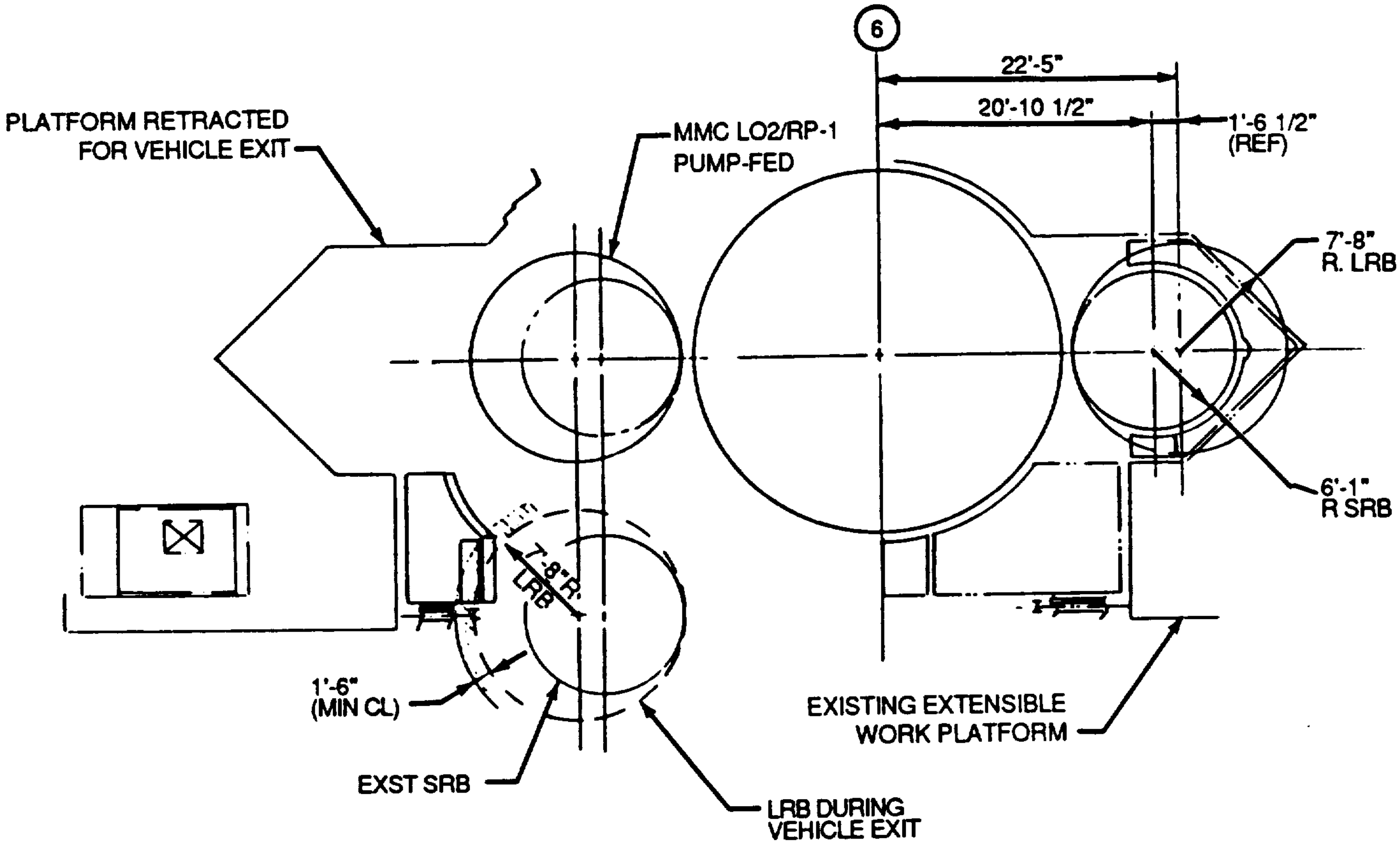


Figure 3.2.3.2.-2 Plan View LRB Typical Infringement
LO2/RP-1 Pump-Fed (MMC).

3.2.3.3 VAB Door Exit Clearance

VAB exit door for SRB/ET/Orbiter stack is 71 ft 1 inch wide. Door clearances have been evaluated for seven cases and have been tabulated in figure 3.2.3.3-1. Figure 3.2.3.3-2 shows least and worst cases of LRBs. All combinations of LRBs with ET/Orbiter clear the VAB door.

3.2.3.4 Applicable Documents and Drawings

VAB door High Bay 1 79K09164
VAB door High Bay 1 79K05424
ICD-2-0A001, Rev H Shuttle System/Launch Platform Stacking and VAB Servicing

3.2.4 High Bay 4 Integration Cell Activation Requirements

High Bay 4 of the VAB will be modified to support the stacking and integration of the ET, LRBs, and Orbiter similar to High Bays 1 and 3. (See Figure 3.2.4.) Many of the facility items required are assumed to be in close proximity to High Bay 4.

3.2.4.1 Facility Requirements to Support Activation

Sources for power gases and water currently exist in the VAB, and all that should be required to do is tap into these systems.

Electrical AC and DC power are required. Specific facility power requirements are covered in paragraph 3.1.6.

Pneumatics A shop air system is required for HVAC controls and tools. This will be supplied from the existing Utility Annex. A tube bank is required for backup. Facility nitrogen and helium gas sources are located between High Bays 2 and 4. Specific pneumatic requirements for ETs and LRBs are similar to those for the processing and storage facility. See paragraph 5.1.1.

Heating, Ventilating, and Air Conditioning Two ECS stations are required to be located on Towers B and C (1 each) of High Bay 4 to deliver conditioned air for Orbiter and LRB skirt, midbody, and nose purge areas.

ALL LRB CONFIGURATIONS CLEAR THE VAB DOORS
DOOR OPENING 71' 1"

LRB TYPE	BOOSTER DIA.	CLEARANCE	ET C/L TO LRB C/L
GDSS LO2/RP-1 (PUMP-FED)	14'-1"	6'-8"	21'-10"
GDSS LO2/RP-1 (PRESSURE)	15'-0"	5'-9"	22'-3 1/2"
GDSS LO2/LH2	16'-2"	4'-7" (SHOWN)	22'-10 1/2"
GDSS LO2/CH1	15'-0"	5'-9"	22'-3 1/2"
MMC LO2/RP-1 (PUMP-FED)	15'-4"	5'-5" (SHOWN)	22'-5 1/2"
MMC LO2/RP-1 (PRESSURE)	16'-2"	4'-7"	22'-10 1/2"
PRESENT SRB	12'-2"	8'-7"	20'-10 1/2"
GDSS LO2/LH2 (FATBIRD)	17'-8"	3'-1"	23'-7 1/2"

Figure 3.2.3.3-1. Vab High Bay Door Clearance.

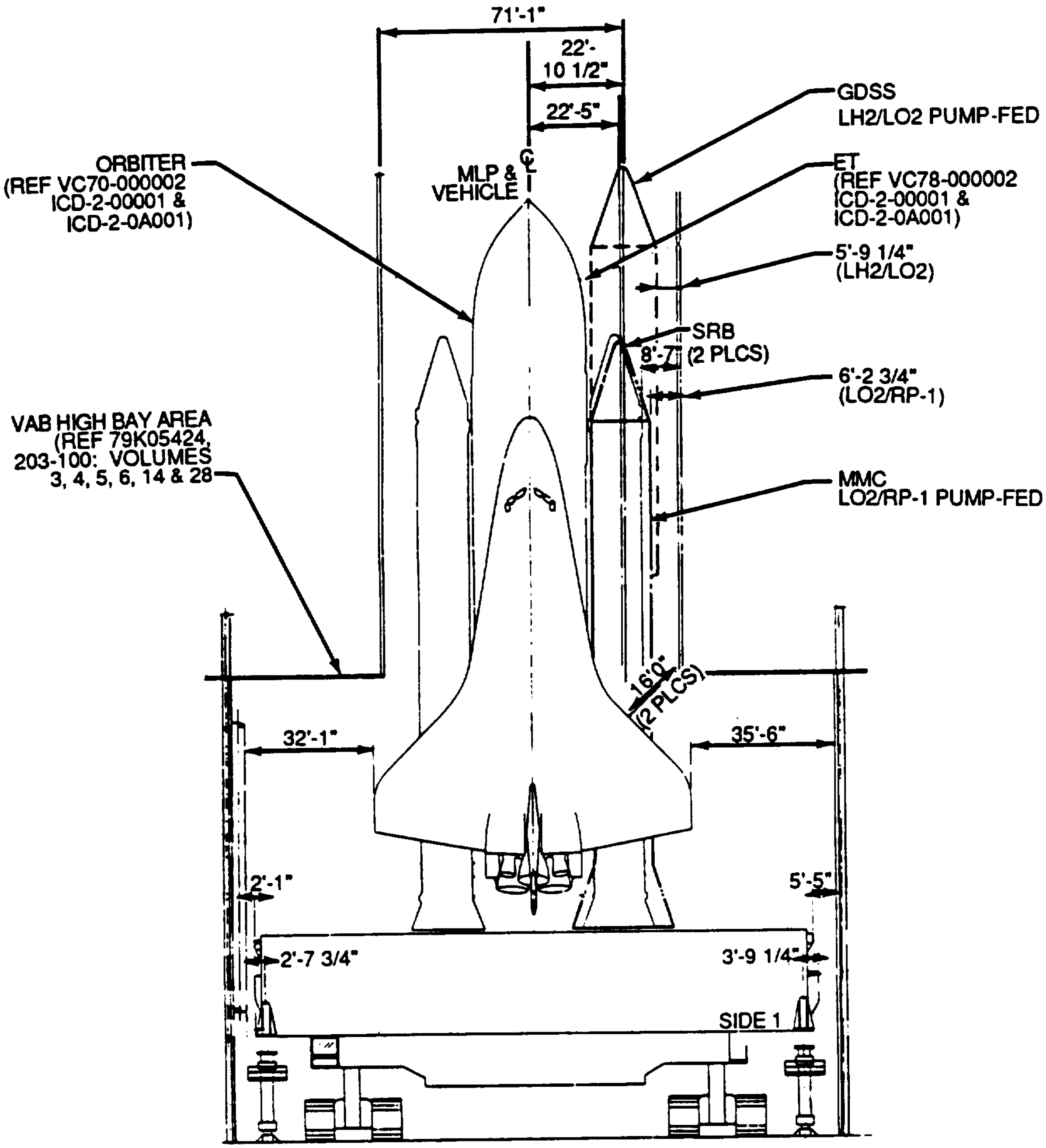
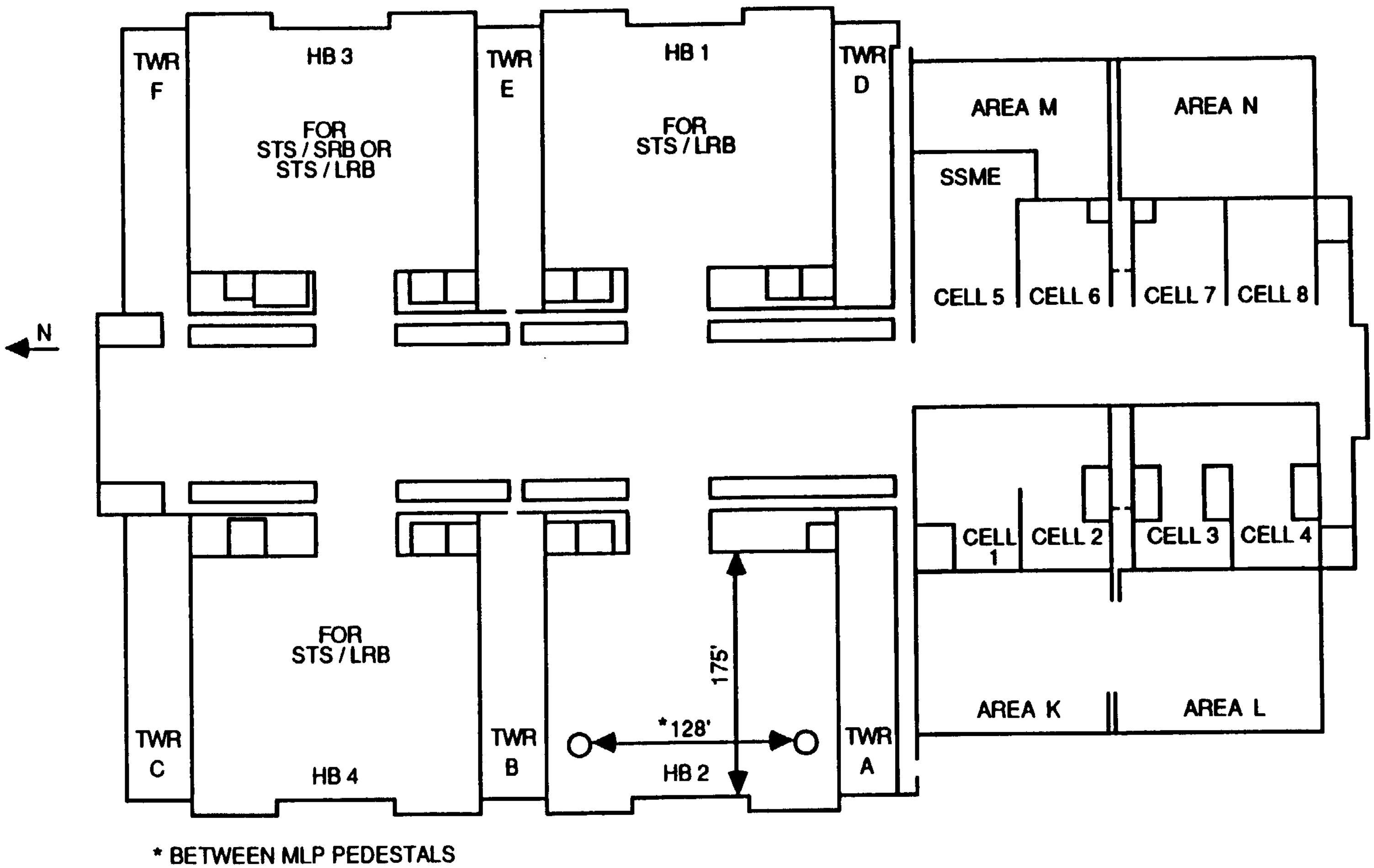


Figure 3.2.3.3-2. Crawler, MLP and Vehicle in Transit Through VAB Doors (East).



81005-01CH

Figure 3.2.4. VAB Plan High Bay 4.

3-3.2 10/28 8:00a

Fire Control Firex water and sprinkler systems are required.

Communication A public address system (PA) and an Operational Interommunication System (OIS) voice recorder are required.

Utilities Potable water is available for safety showers, eye wash, restrooms, and the HVAC chilled water system; firex water is available for connection of the fire control system.

MLP Pedestals Six new MLP pedestals must be provided in High Bay 4.

3.2.5 Reactivation of Crawlerway to VAB High Bay 4.

Paragraph 3.2.5 presents the requirements for reacting the section of abandoned crawlerway leading to VAB High Bay 4 from the MLP parksite.

The section of crawlerway that requires refurbishment starts northwest of the OMRF where it ties into the existing crawlerway and proceeds east from the OPF to the northwest side of the VAB (High Bay 4).

3.2.5.1 Impacts

As shown in Figure 3.2.5.1, the OPF modular complex will require relocation. A section of the Orbiter towway from the OPF to the VAB will have to be modified to be compatible with both the Orbiter and crawler. A parking area is located east of the OPF modular complex will require a portion to be deleted; a section of train rail will have to be rerouted; and a section of fence crossing the crawlerway site will be relocated. Various underground utility lines and manholes will require relocation, and the OMRF ECS duct from the VAB, which runs along the west side of the parking area and under the towway, must be relocated.

3.2.5.2 Reactivation Requirements

The old crawlerway bed must be prepared with a compacted base course, as required. A bituminous prime coat should be applied and the bed resurfaced with gravel, with curbs added.

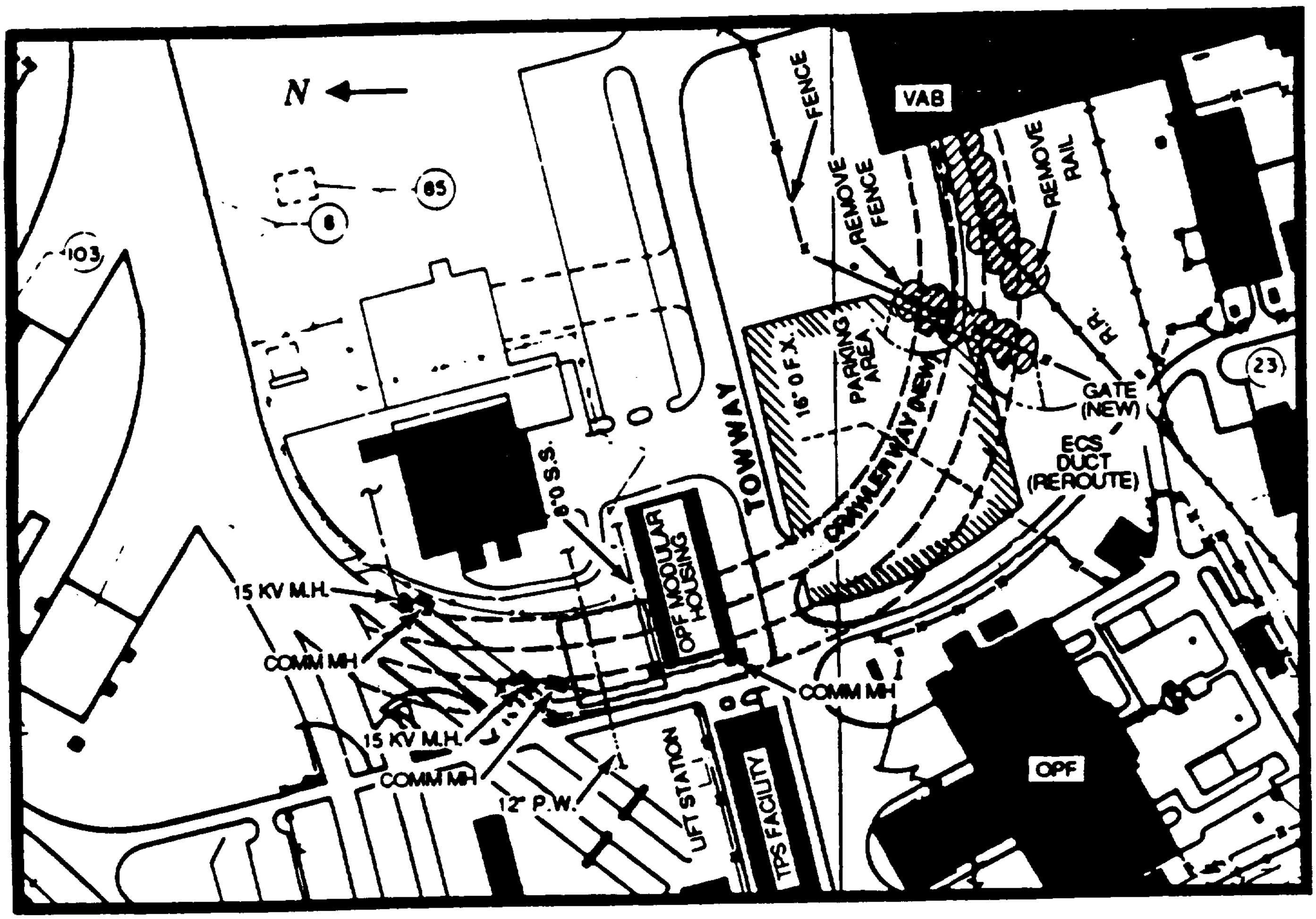


Figure 3.2.5.1 VAB High Bay 4 Crawlerway Site Plan.

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3-3.2 10/28 8:00a

Utility and communication lines beneath the crawlerway will require relocating and adequate protection against crawler loads. New communication and electrical manholes are required. The ECS crosscountry duct can be rerouted adjacent to the crawlerway and new gates installed where the fence crosses the crawlerway.

3.3 MOBILE LAUNCH PLATFORM (MLP)

The MLP provides the structure for the interface between the ground systems in support of the SSV. This section will discuss how the liquid rocket booster changeover will affect the current MLP configuration by the impacts on the existing structure of larger exhaust holes, the requirement for new propellant tunnels, and the engine removal/installation capability.

3.3.1 Evaluation of Existing MLP for Exhaust Hole Modification

Three MLPs are available for SRB/ET/Orbiter launch: MLP-1, MLP-2, and MLP-3. The main structural configurations of these MLPs are very similar. A study was conducted for impacts if converted for LRB/ET/Orbiter Launch.

3.3.1.1 Assumptions and Groundrule Constraints

The basic assumption of the load carrying capability of the MLPs was made on total glow weight of stack. Figure 3.3.1.1 lists the total GLOW (gross lift-off weight) of the LRB stacks versus an SRB stack (except GDSS LOX/RP1 pressure-fed). Since the SRB stack weighed more than any LRB stack, it was assumed that existing MLPs were capable of carrying the LRB loading configuration. Using the above assumption, the impact study was limited to the exhaust hole area. The groundrules for the study were that the MMC LOX/RP1 pump-fed and the GDSS LOX/RP1 pump-fed configurations would be used. Since G-20 is a main structural framing girder, any relocation will be avoided.

3.3.1.2 Exhaust Hole Impacts

The impacts on exhaust holes have been studied for the MMC and GDSS LOX/RP1 pump-fed configurations.

MMC LOX/RP1 Pump-Fed Configuration Impacts The impacts of this configuration on the existing MLP structural design are shown in Figures 3.3.1.2-1, 3.3.1.2-2, and 3.3.1.2-3.

Figure 3.3.1.2-1 shows in plan view the impacts on existing girders as well as the modifications required to relocate girders G-22, G-23, G-24, and G-25. Figure 3.3.1.2-2 shows the LRB exhaust hole width required. Figure 3.3.1.2-3 shows the exhaust hole length. Figure 3.3.1.2-4 lists com-

PROPERTIES	MMC		GDSS					SRB
<u>PROPELLANTS</u>								
OXIDIZER	LOX	LOX	LOX	LOX	LOX	LOX	LOX	SOLID
FUEL	RP-1	RP-1	RP-1	RP-1	LH2	CH4	LH2	
TYPE	PUMP	PRESSURE	PUMP	PRESSURE	PUMP	SPLIT/ EXPANDER	PUMP/FAT	
<u>VEHICLE</u>								
LENGTH (FT)	150.9	162.7	149.5	199.5	190.5	150.47	169.5	149.0
DIA (FT)	15.3	16.2	14.1	15.0	16.2	15.0	17.7'	12.3
SKIRT	22'-11-1/4"	26'-0"	25'-11-1/8"	26'-9-1/2"	22'-3-1/2"	27'-3-1/8"	24'-4"	-
<u>WEIGHT</u>								
GLOW	4,130,505	4,530,410	3,974,000	5,190,644	3,416,000	3,864,000	3,400,816	4,525,000
LRB (DRY)	116,665	199,520	114,039	227,533	119,523	104,132	104,339	198,000
LRB (WET)	1,092,000	1,300,860	1,015,195	1,633,178	736,111	960,164	720,932	1,300,356

Figure 3.3.1.1. Data for LRB Configurations.

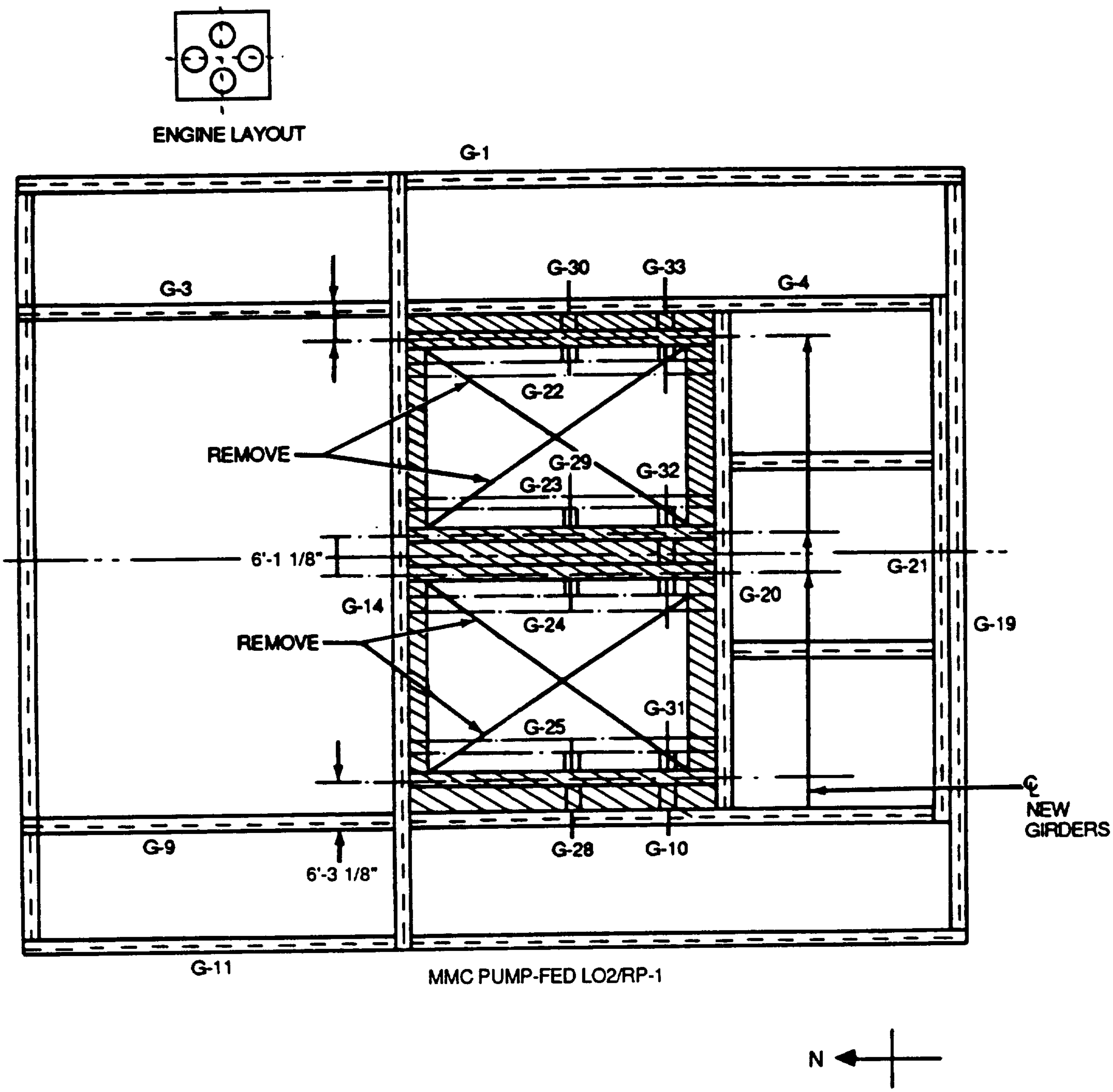
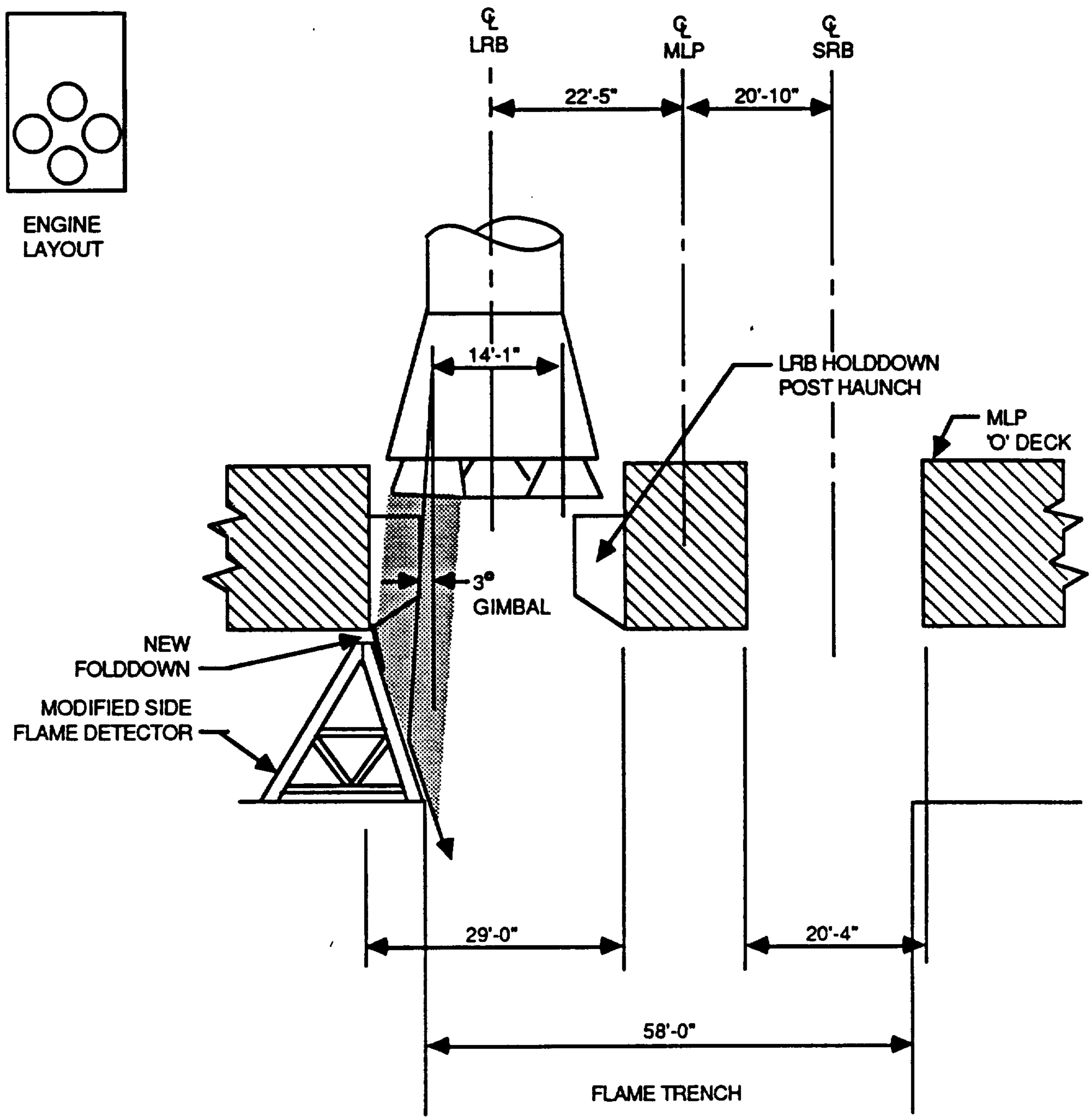


Figure 3.3.1.2-1. MLP Exhaust Hole Modifications for MMC Pump-Fed Configuration Plan View.



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Figure 3.3.1.2-2. MLP Exhaust Hole Modification for MMC Pump-Fed Configuration (South Elevation).

3-3 12/1 0800

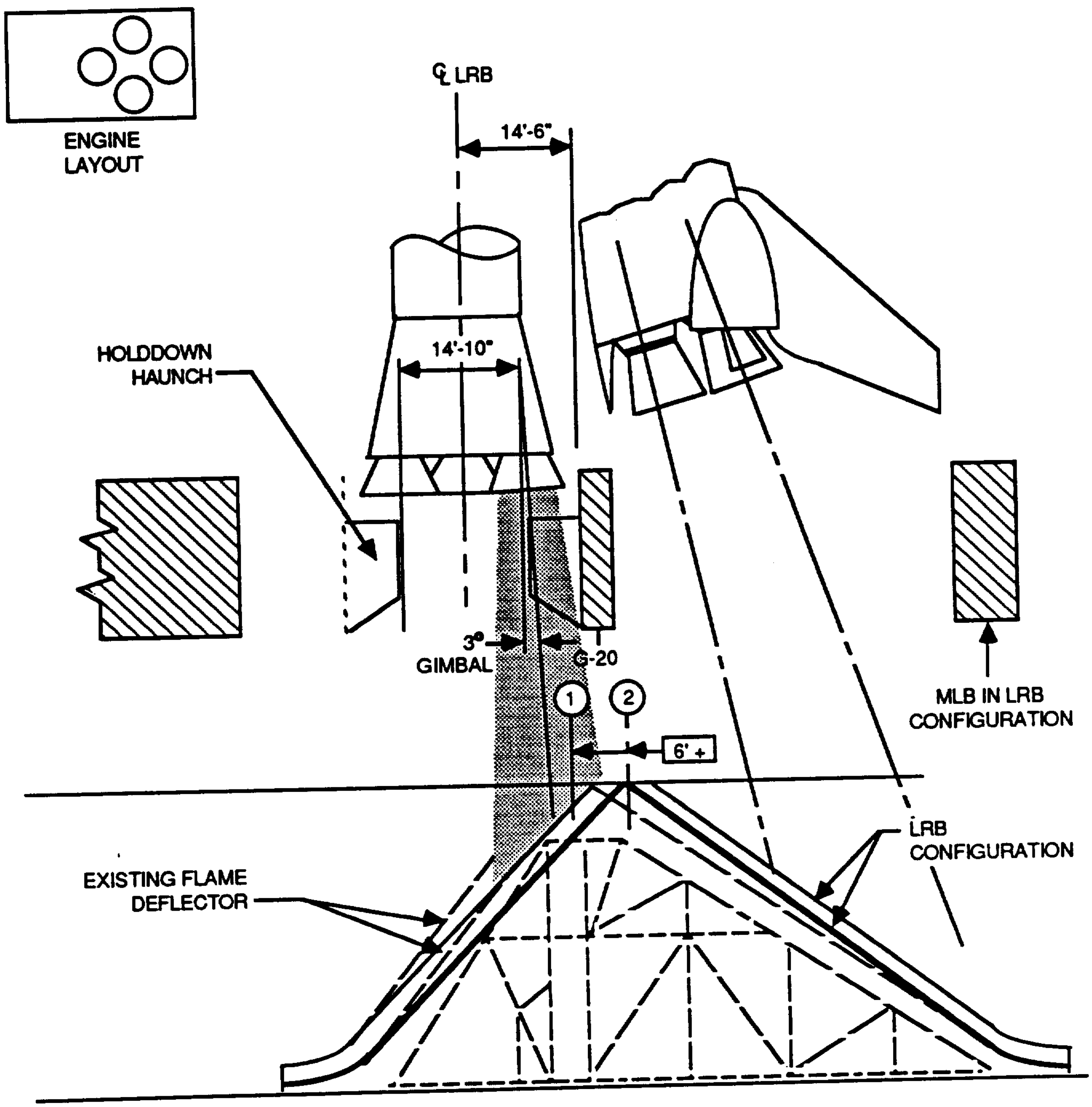


Figure 3.3.1.2-3. MLP Exhaust Hole Modification for MMC Pump-Fed Configuration (West Elevation).

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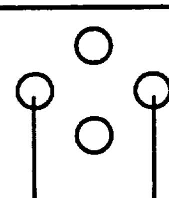
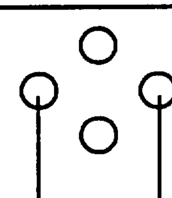
	LO2/RP-1 PUMP-FED	LO2/RP-1 PRESS-FED
BOOSTER DIAMETER	15'-3"	16'-2"
SKIRT DIAMETER	22'-11/4"	26'-0"
℄ LRB FROM ℄ ET	22'-5"	22'-9 1/2"
EXHAUST HOLE SIZE	29'-0" X 41'-4 1/4"	32'-0" X 41'-4 1/2"
IMPACT TO G-20 AT 3° ENGINE GIMBAL	APPROX 1.9' CLEARANCE FROM BLAST SHIELD	APPROX .2' CLEARANCE FROM BLAST SHIELD
℄ G-10 TO RELOCATED G-25 AND G-4 TO RELOCATED G-2	6'-3 1/8"	3'-4 5/8"
℄ ET TO RELOCATED G-23 AND G-24	6'-1 1/8"	4'-11 5/8"
LOCATION OF NEW HOLDDOWN POST HAUNCHES	TBD	TBD
ENGINE LAYOUT	 14'-1"	 15'-10"

Figure 3.3.1.2-4. Comparison Between MMC's Pump-Fed and Pressure-Fed Concepts.

parisons between pump-fed and pressure-fed concepts. It also lists exhaust hole sizes, girder location clearances, and impacts. For example: Girder G-20 goes away totally in the pressure-fed concept.

GDSS LOX/RP1 Pump-Fed Configuration Impacts The impacts of this configuration on the eisting MLP structural design are shown in Figures 3.3.1.2-5, 3.3.1.2-6, and 3.3.1.2-7.

Figure 3.3.1.2-5 shows in plan view the impacts on existing girders as well as modifications required to relocate G-22, G-23, G-24, and G-25. Figure 3.3.1.2-6 shows LRB exhaust hole width required. Figure 3.3.1.2-7 shows the exhaust hole length. This figure also shows the new girders required for supporting the holddown system. These girders are located in LRB exhaust holes and will be subjected to LRB blast pressure and prolonged high temperatures.

Figure 3.3.1.2-8 shows a comparison between GDSS LOX/RP-1 pump-fed LOX/LH2 and LOX/CH4 concepts. The table lists the size of exhaust holes, location of girders, and impact to existing girder G-20.

3.3.1.3 Conclusions and Recommendations

Besides G-20 being the main girder of MLP structural framings and relocatiing it would not be feasible, as discussed in Paragraph 3.3.1.2, any relocation north of the present position would make the SSME exhaust hole smaller. Relocating G-20 toward the south from its present position would give it heavy exposure to LRB engine blast.

To meet the groundrules, all structural designs require a minimum of three exit nozzle diameter clearance distances from flat surface, as stated in Paragraph 3.5 of "Standard for, Flame Deflector Design (KSC-STD-Z-0012)."

Relocating girder G-20 would seriously affect the structural integrity of the MLP, and total omission is not feasible. Design feasibility of providing a new girder in the LRB exhaust holes (GDSS concept) may be in question.

Modification of MLP-1&2 from the old Apollo system took 5 years each. All LRB modifications would take about the same length of time or more if permitted by design feasibility.
It is therefore recommended that a new MLP be built to start the LRB program.

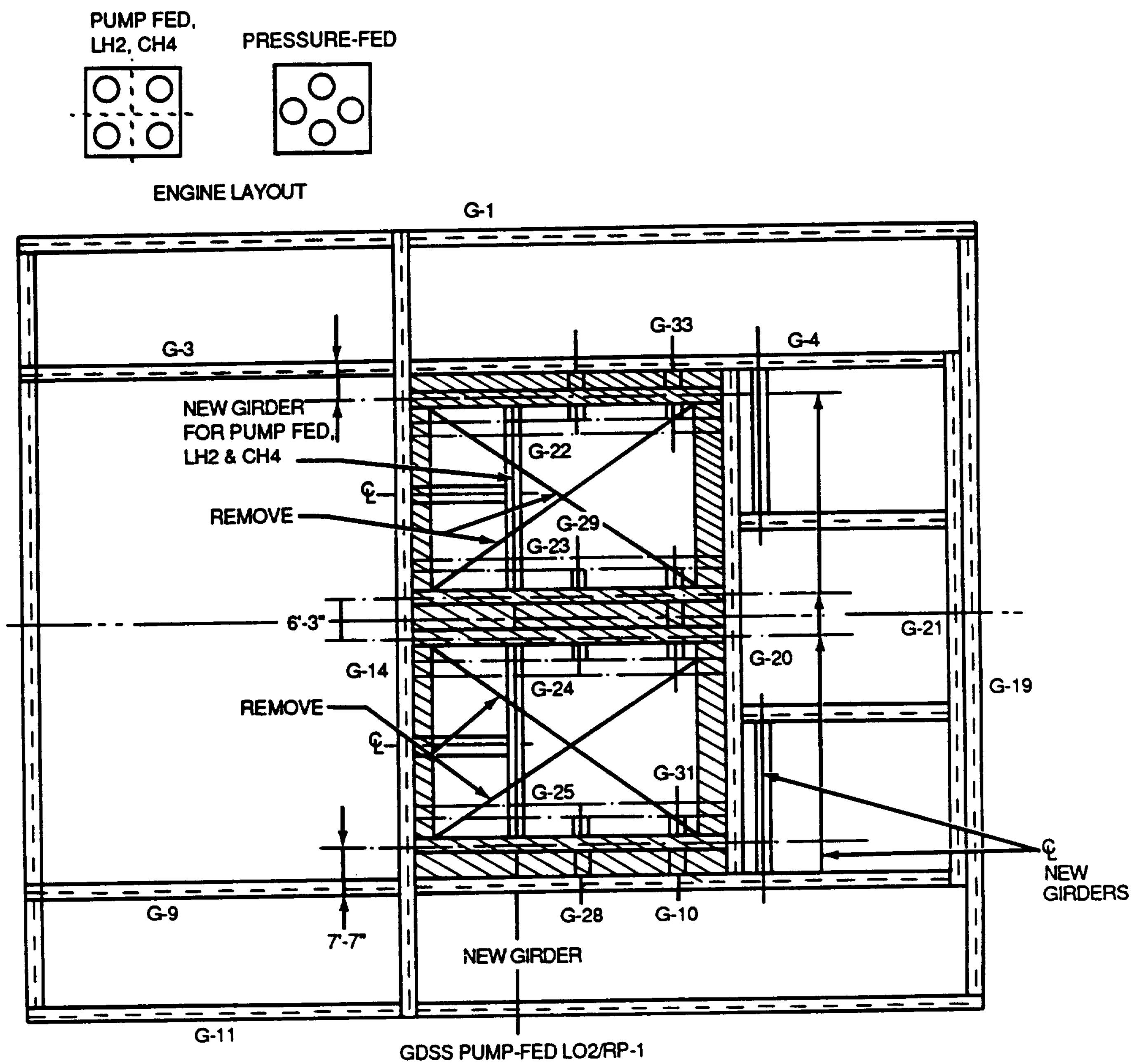


Figure 3.3.1.2-5. MLP Exhaust Hole Modifications for GDSS LRB.

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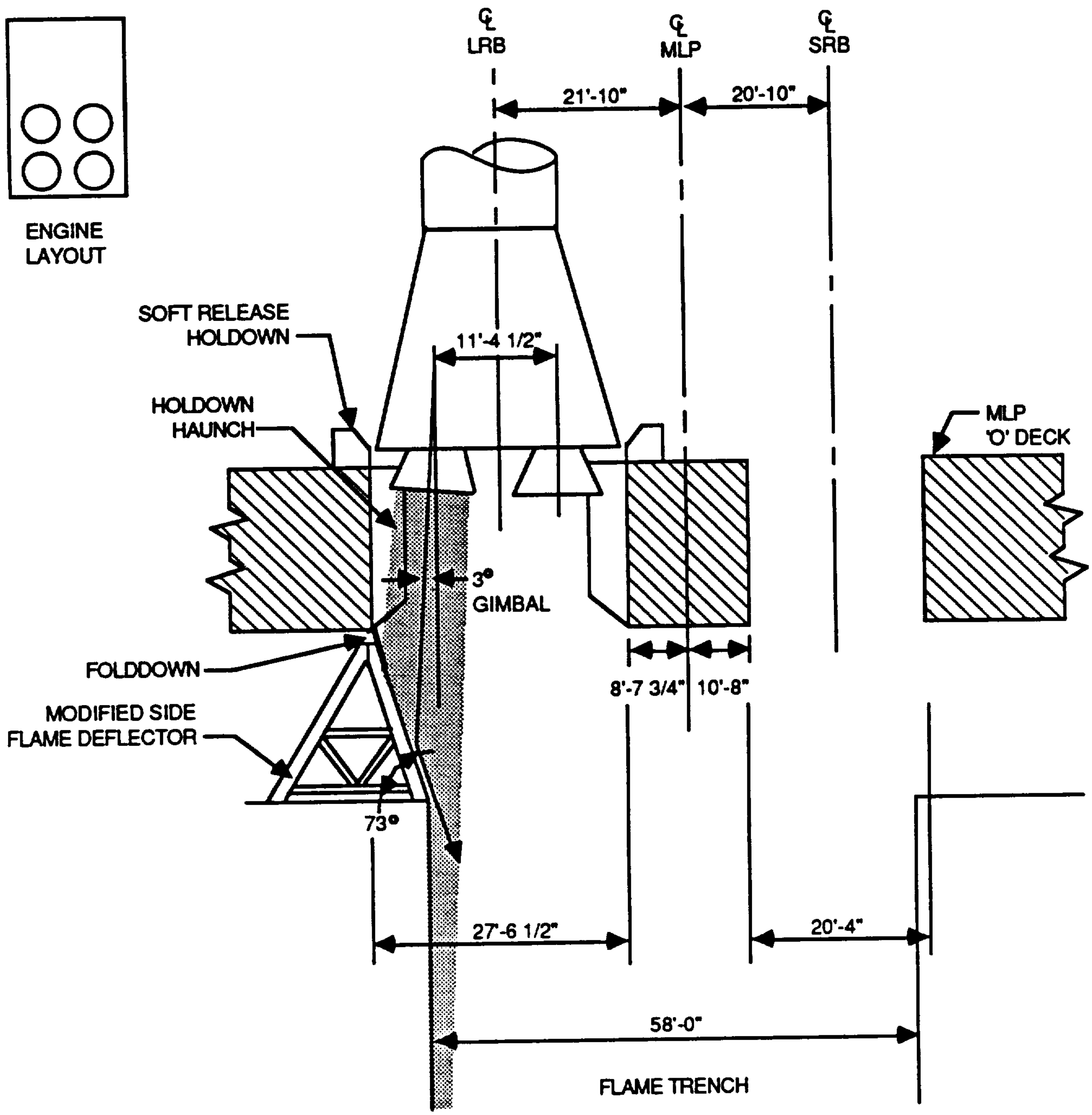


Figure 3.3.1.2-6. MLP Modification for GDSS
Pump-Fed Configuration

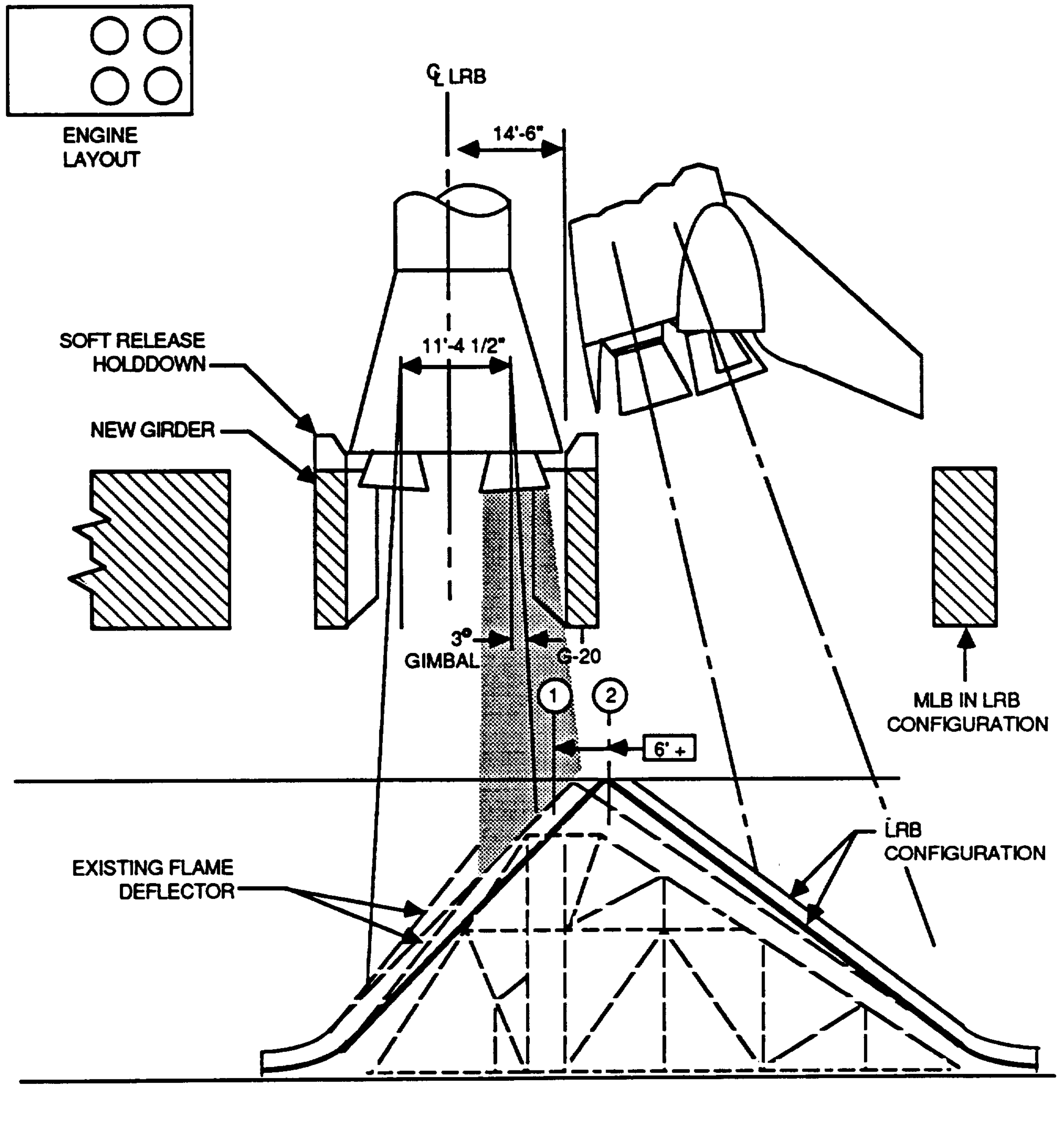


Figure 3.3.1.2-7. GDSS Concept (Pump-Fed Configuration).

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3-3.4 12/1 0800

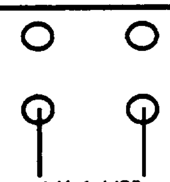
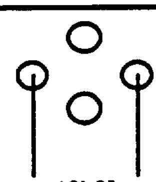
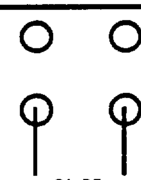
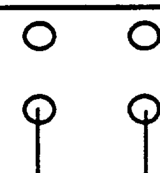
	LO2/RP-1 PUMP-FED	LO2/RP-1 PRESS-FED	LO2 / LH2	LO2 / CH4
BOOSTER DIAMETER	14'-1"	15'-0"	16'-2"	15'-0"
SKIRT DIAMETER	25'-11 1/8"	26'-9 1/2"	22'-3 1/2"	27'-3 1/4"
℄ LRB FROM ℄ ET	21'-10"	22'-3 1/2"	22'-10 1/2"	22'-3 1/2"
EXHAUST HOLE SIZE	41'-4 1/2" X 27'-6 1/4"	41'-4 1/2" X 27' 6-1/4"	41'-4 1/2" X 27'-6 1/4"	41'-4 1/2" X 27'-6 1/4"
IMPACT TO GIRDER G-20 AT 3° ENGINE GIMBAL	~ 2.5' CLEARANCE FROM BLAST SHIELD	~ 2.0' CLEARANCE FROM BLAST SHIELD	~ 4.2' CLEARANCE FROM BLAST SHIELD	~ 2.4'CLEARANCE FROM BLAST SHIELD
℄ ET TO RELOCATED G-23 AND G-24	6'-3"	6'-8 1/2"	8'-3 1/2"	6'-8 1/2"
℄ G-10 TO RELOCATED G-25 AND G-4 TO RELOCATED G-22	7'-7"	7'-1 1/2"	5'-6 1/2"	7'-1 1/2"
LOCATION OF NEW GIRDER TO SUPPORT RELEASE MECH FROM ℄ LRB	15'-7"	15'-7"	15'-7"	15'-7"
HAUNCH SIZE & SUPPORTS	TBD	TBD	TBD	TBD
ENGINE LAYOUT	 11'-4 1/2"	 12'-3"	 9'-8"	 11'-10 1/2"

Figure 3.3.1.2-8. Comparisons Between GDSS LRB Concepts For MLP Modifications.

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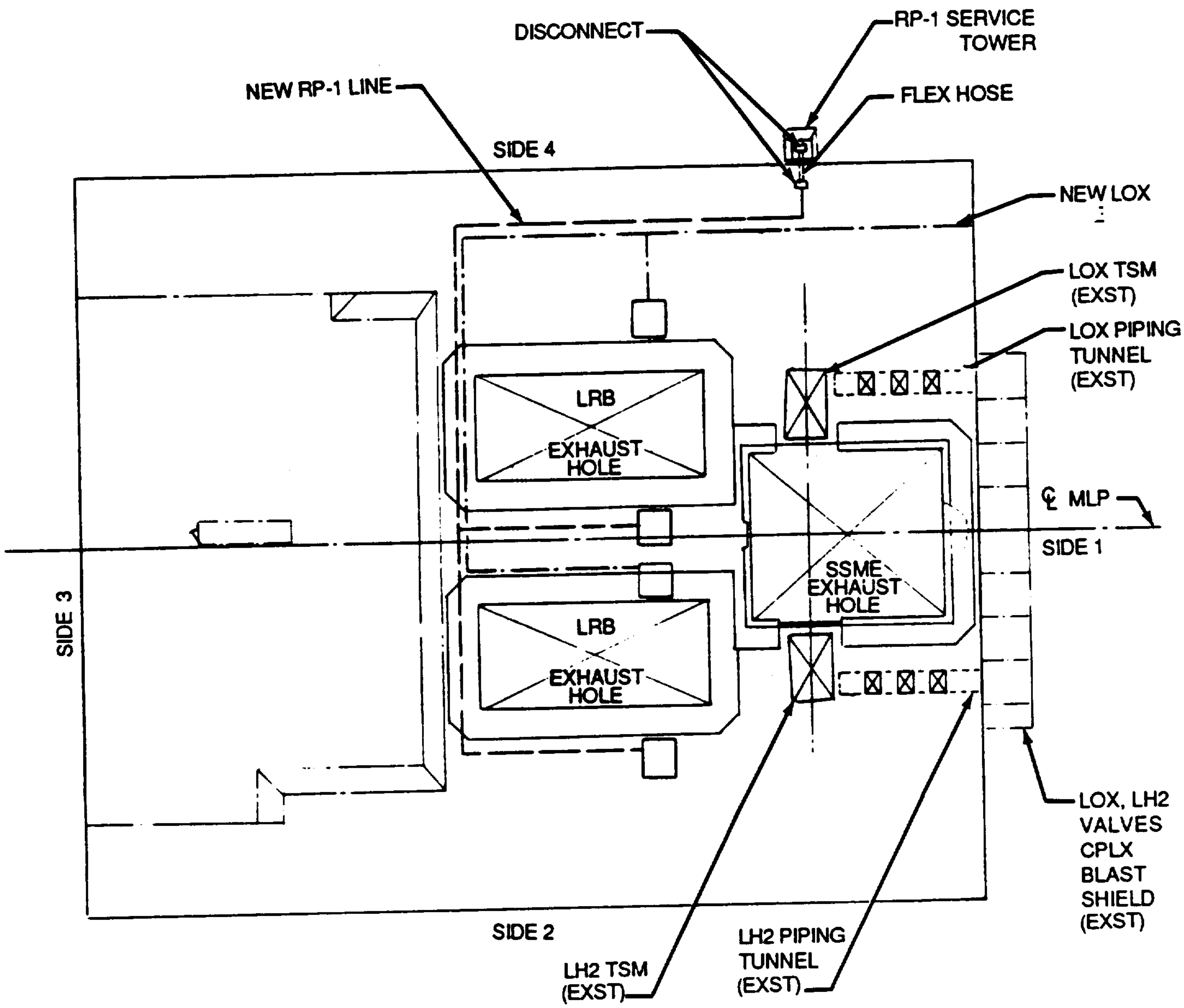


Figure 3.3.2.1-1. MLP Propellant Tunnel Concepts (Plan View).

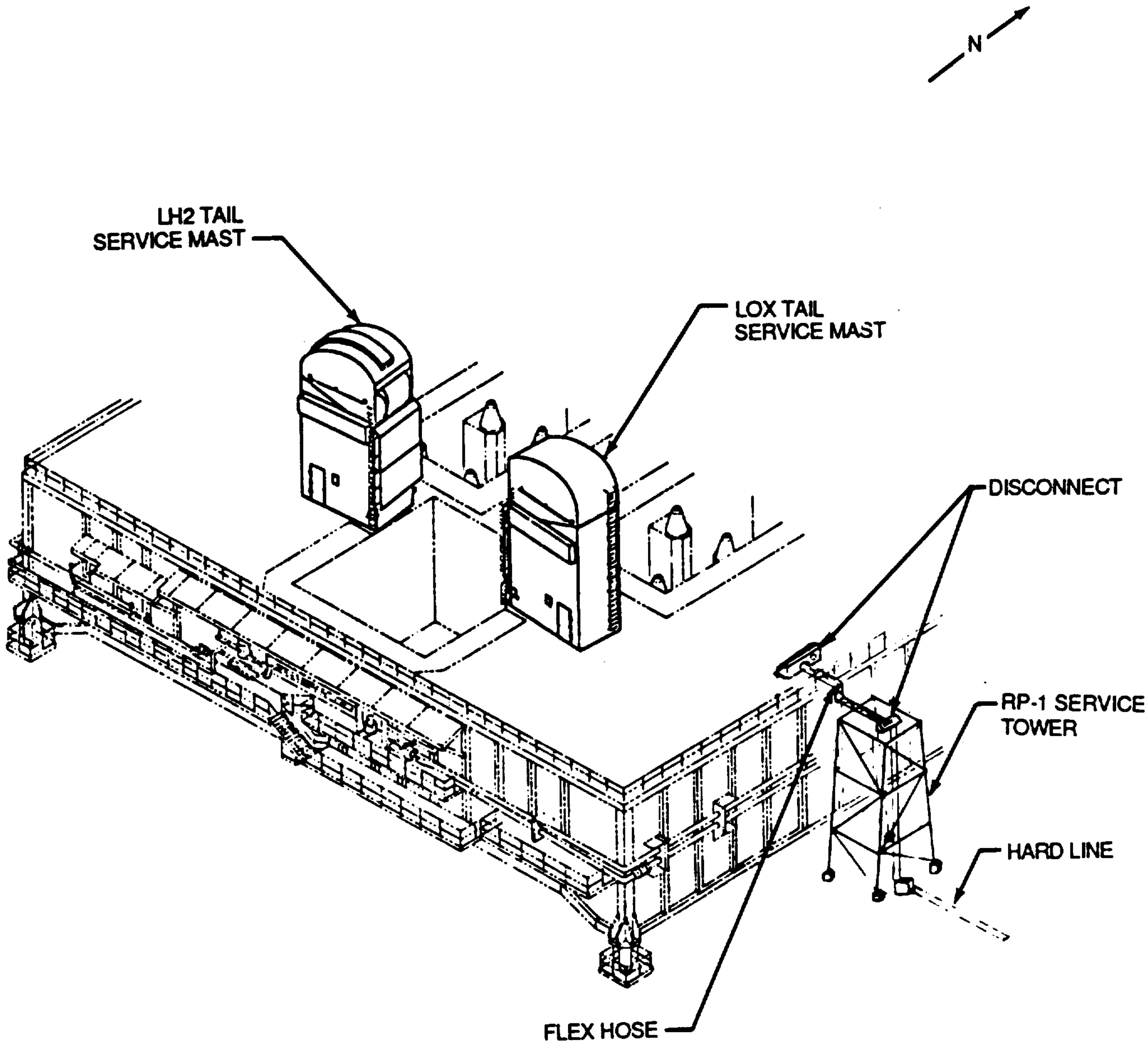


Figure 3.3.2.1-2. RP-1 Portable Service Tower.

3.3.2.3 References

MLP-2 drawing - 79K11397
General Arrangement, Plan Deck "0"

3.3.3 LRB Engine Level Access

Access for engine maintenance can be provided by building platforms similar to the SSME platforms. (See Figures 3.3.3-1 and 3.3.3-2.) At present the SSME service platforms (Figure 3.3.3.1) are lifted into the Orbiter exhaust hole of MLP utilizing winches. Similar service platforms are used for SRBs.

3.3.4 Tail Service Masts (TSMs)

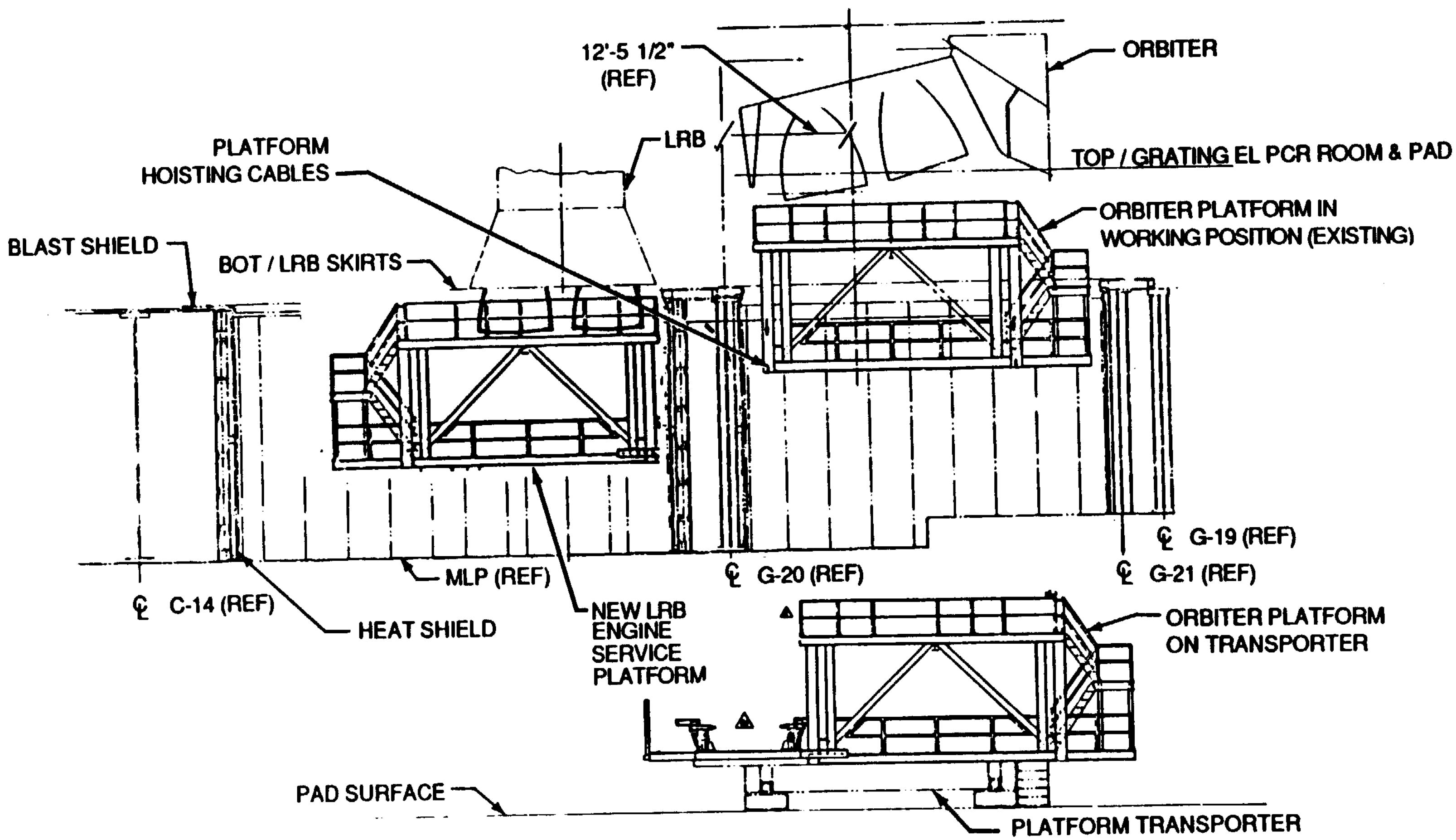
This section will determine the impact to existing liquid oxygen and liquid hydrogen TSMs as the result of a conversion from SRBs to LRBs in the Space Shuttle program.

3.3.4.1 System Description

Each MLP has one liquid oxygen (LOX) and one liquid hydrogen (LH2) TSM as shown on Figure 3.3.4.1-1. Figure 3.3.4.1-2 shows the mechanics of the TSM retraction process. The TSMs are functionally the same; the major difference lies in the number of lines, electrical and fluid. Structural housing and some of the basic mechanical components are on opposite sides.

At launch, the signal for initiation reaches the pyro-separation bolt. The dropweight falls, applying lanyard tension to disconnect, and retracts the mast and carrier, which is followed by bonnet closing.

Mast and Links - The mast supports the line coming from inside the MLP and going to the Orbiter umbilical carrier. The mast, along with the links and carrier plate, rotates approximately 20 degrees away from the Orbiter. The four links reduce the peak transient effects and support the carrier after disconnect.



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Figure 3.3.3-1. LRB/Orbiter Engine Service Platforms (MLP).

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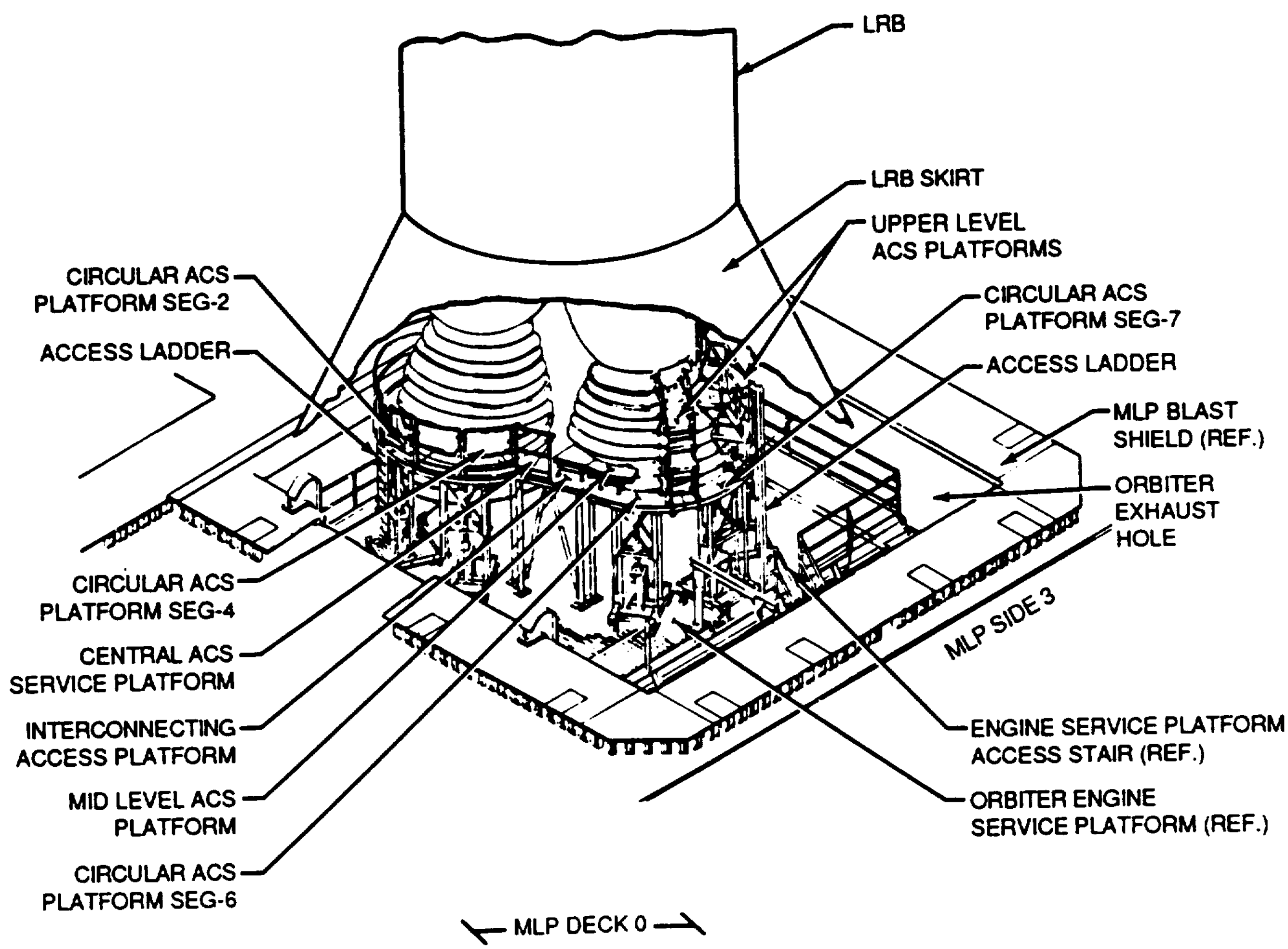
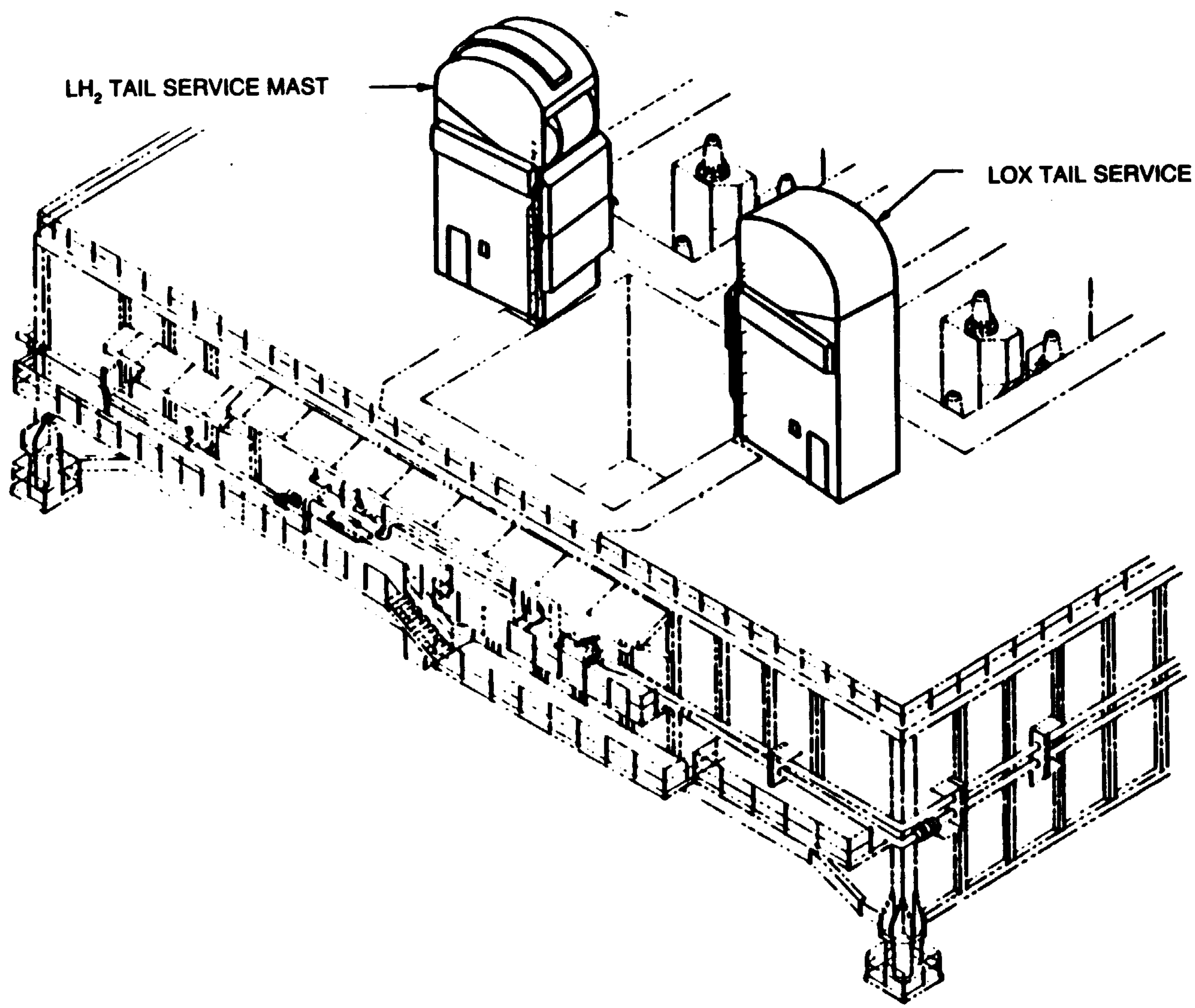


Figure 3.3.3-2. LRB Engine Access Platforms (MLP).

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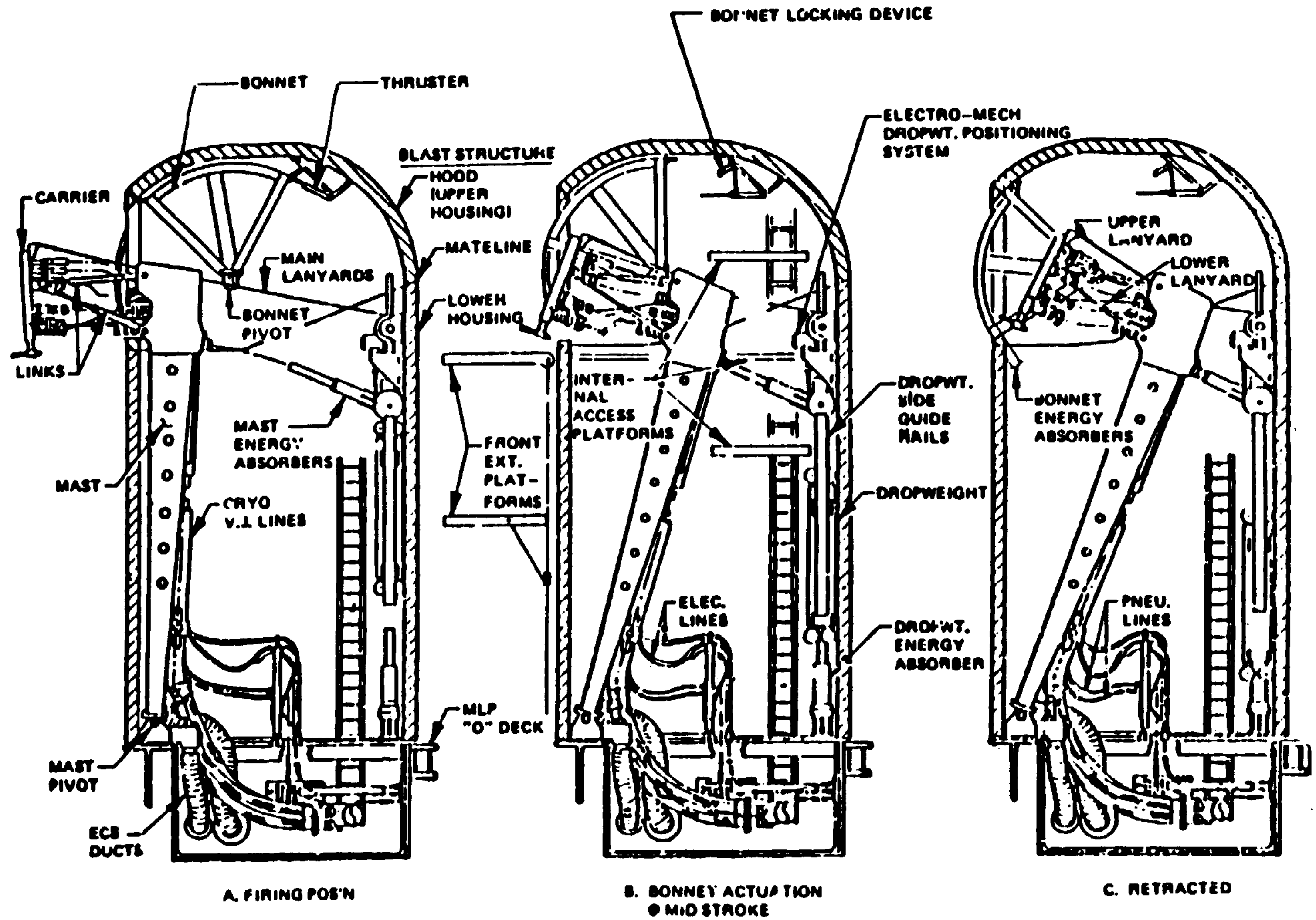
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Figure 3.3.4.1-1. LH2 and LOX Tail Service Masts.

3-3.3 10/28 8:00a



81005-01DI Figure 3.3.4.1-2. TSM Retraction Process (LOX Shown, LH2 Similar). 3-3.3 10/28 8:00a

Dropweight System - The dropweight provides the lanyard tension for the carrier plate to disconnect and retract. The power comes from the potential energy stored in the dropweight when it is elevated to its launch position. The dropweight energy is transferred through a lanyard system to the carrier and from carrier to the mast through the links.

Bonnet System - The bonnet is a structural steel semicylindrical door, that closes the TSM hood after the carrier plate is retracted. The thruster holds the bonnet open and automatically provides a release mechanism when "fired." The thruster must be released from the bonnet at the end of the stroke.

In addition, there are energy absorbers to absorb mast, bonnet, and dropweight decelerations; electrical power inside each TSM; pneumatic power at the utility access panel; and internal platforms and ladders for service operations. Steel housing protects internal equipment.

3.3.4.2 Assumptions

Vehicle vibrations would be the same at Orbiter main engine firing and at T-0. Vehicle clearance from the closest point of TSM housing is assumed to be adequate. Drift would be the same as main engines crossing TSM housing. Vehicle excursion would be within the KSC Filament Wound Case in ICD-2-0A002, Rev. L. (See figure 3.3.4.2.)

3.3.4.3 Modification Concept If Required

The modification concept involves accommodating new SSV interface excursions. The functional requirement and operational concept of TSM equipment would remain the same. The interfaces during stacking, 60-knot wind deflection, thrust buildup, and SSME shutdown excursions would be within the Filament Wound Case of ICD-2-0A002, Rev. L. The modified TSM system would require Launch Equipment Test Facility (LETF) testing. The component modifications illustrated in Figure 3.3.4.3 would be required as follows:

a. Lengthen fill and drain flex hoses.
b. Install new upper and lower links.
c. Modify Environmental Control System (ECS) elbows.
d. Lengthen lanyards.
e. Remove shims from energy absorber mounts.

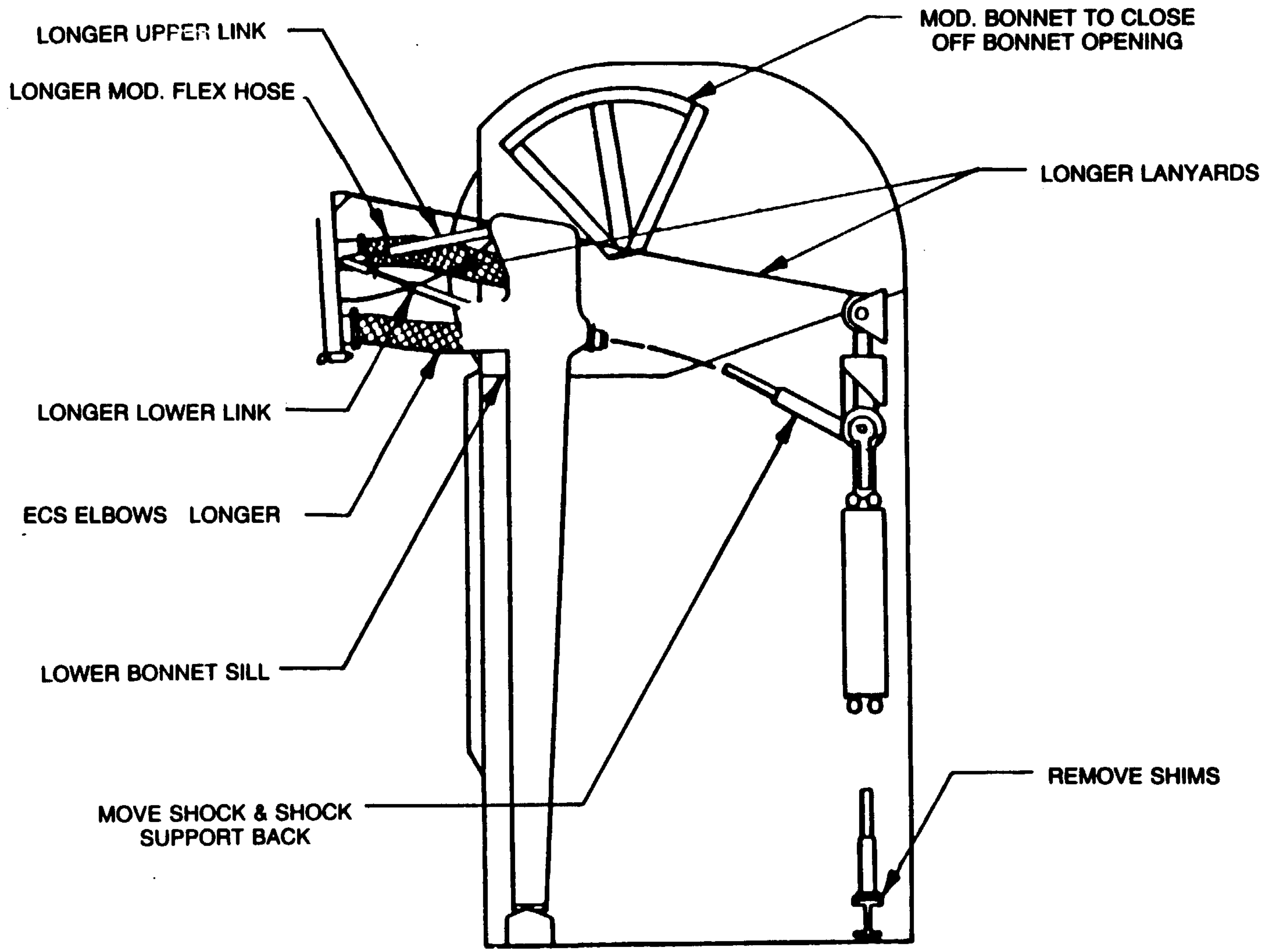
SSV INTERFACE EXCURSIONS				
ORBITER AXIS	SRB CONFIGURATION		LRB CONFIGURATION	
	+	-	+	-
X	7.1	11.1	7.3	14.1
Y	2.4	3.1	2.6	2.8
Z	2.0	1.5	2.1	1.3

NOTES:

LRB EXCURSIONS ARE BASED ON KSC FILAMENT WOUND CASE EXCURSION (ICD-2-OAOO2 REV. L)

SRB EXCURSIONS ARE BASED ON KSC STEEL CASE EXCURSION, (ROCKWELL'S LOADS DATA BOOK JULY 88)

Figure 3.3.4.2. SSV Interfaces Excursions for TSM



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Figure 3.3.4.3. Tail Service Mast Component Modifications.

3-3.3 10/28 8:00a

f. Move mast energy absorber and shock supports.

h. Lower bonnet sill.

3.3.4.4 Conclusions and Recommendations

Since the modifications that would be required to enable the TSMs to support LRBs are not extensive, the concept presented in Paragraph 3.3.4.3 is recommended.

3.4 LAUNCH COMPLEX 39 - PADS A AND B

The Pad provides the capability to check out, service, and launch the SSV. The Fixed Service Structure (FSS) and the Rotating Service Structure (RSS) provide the physical interface using access platforms, swing arms, and umbilicals. In addition, the RSS provides the ability to process Orbiter payloads. The launch pad surface consists of the crawlerway, the flame trench with the flame deflector, and the side flame deflectors. This study evaluates the effects and impacts of modifying these areas of the Pad to support both LRBs and SRBs. Figure 3.4 presents a general arrangement of the Pad area.

3.4.1 Flame Trench

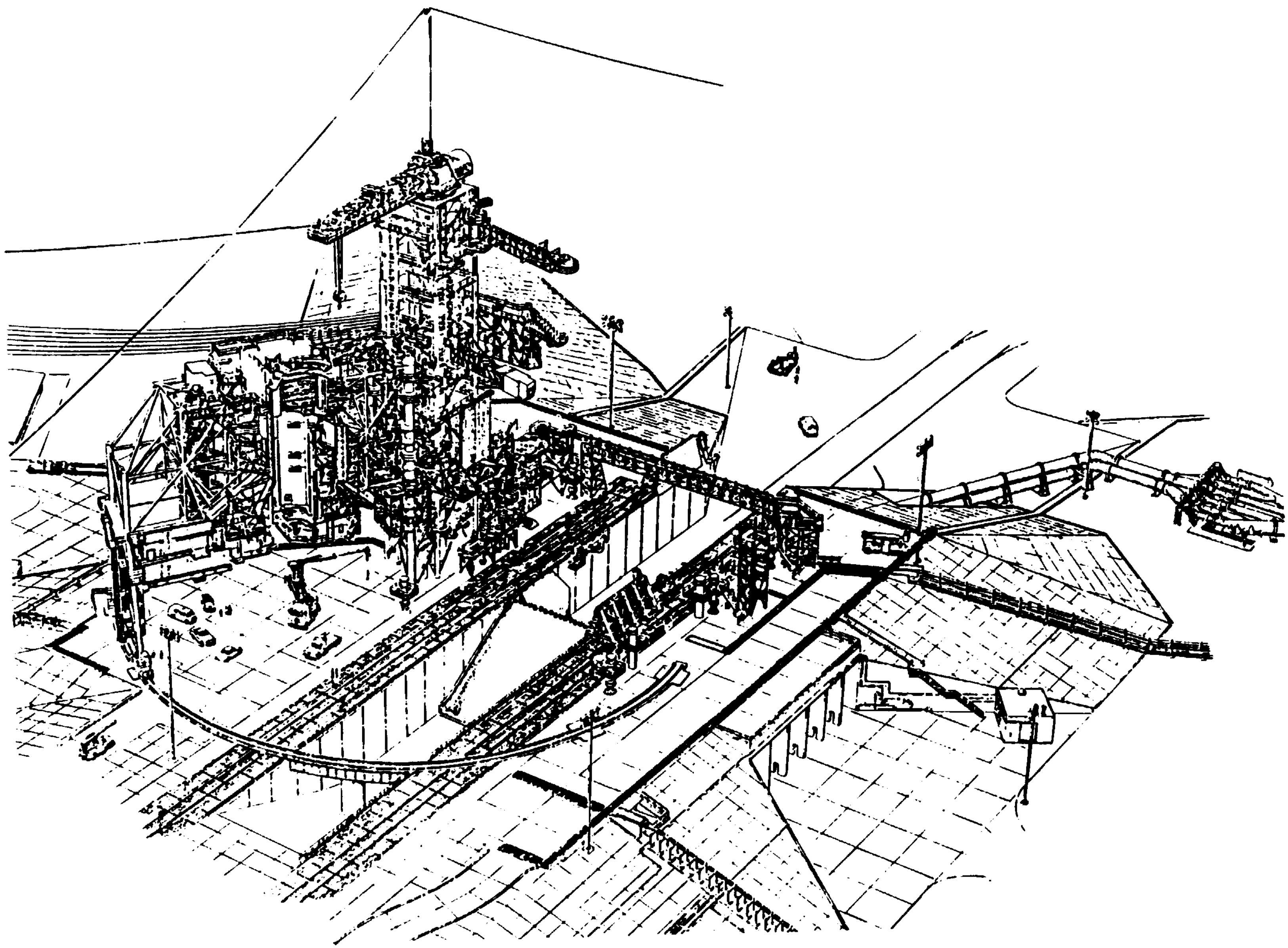
This section analyzes the flame trench based on the basic assumption that modifications to the existing flame trench will not be performed (see Appendix Volume 5 Section 3).

The flame trench can be described as a concrete/steel construction channel that contains the launch exhausts and protects the pad structures from blast and exhaust flames. It provides sufficient height between the engine and the impingement surface, which reduces the possibility of exhaust rebounding back toward the Orbiter. The main flame deflector has two sides; one for the Orbiter main engines and the other for the boosters, which direct the exhaust in the trench.

The study will analyze the impacts on main and side deflectors. The baseline LRBs for the analysis were the GDSS and MMC pump-fed concepts of LOX/RP-1.

3.4.1.1 Side Flame Deflector Impacts

The purpose of the side flame deflectors is to direct the blast and exhaust flames toward the center of the flame trench and to protect the pad structures from damage from these flames. There are two side flame deflectors located on top of the pad surface at the edge of the flame trench. They are made of structural steel, roll in place on top of a rail, and are fastened down prior to launch. They occupy the gap between the bottom of the MLP and the top of the Pad to give maximum protection. See Figures 3.4.1.1-1 and 3.4.1.1-2 for the location of the side flame deflectors and the conceptual configurations for the MMC LOX/RP-1 pump-fed and GDSS LOX RP-1 pump-fed configurations respectively.



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Figure 3.4. Pad Current Configuration.

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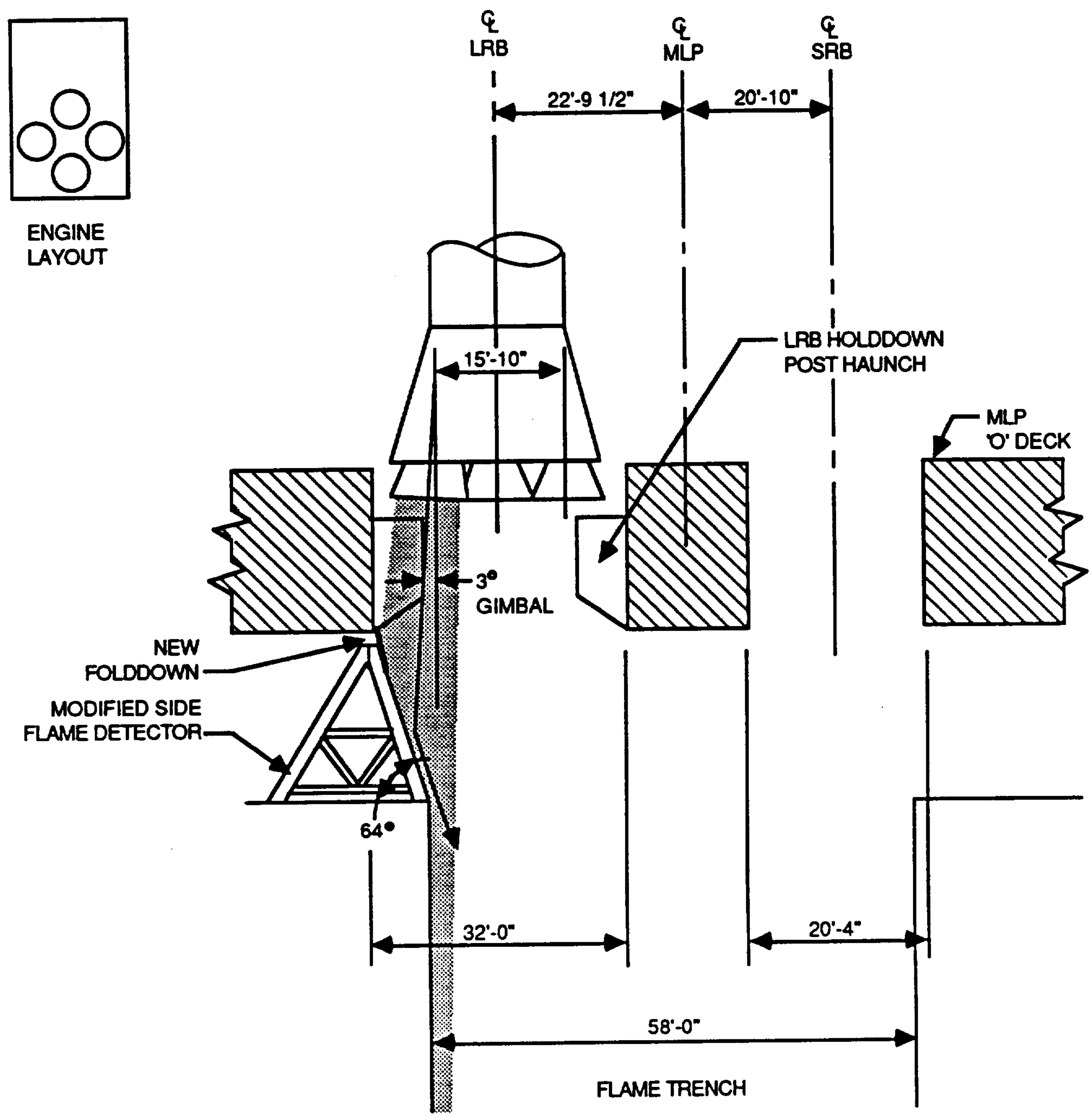
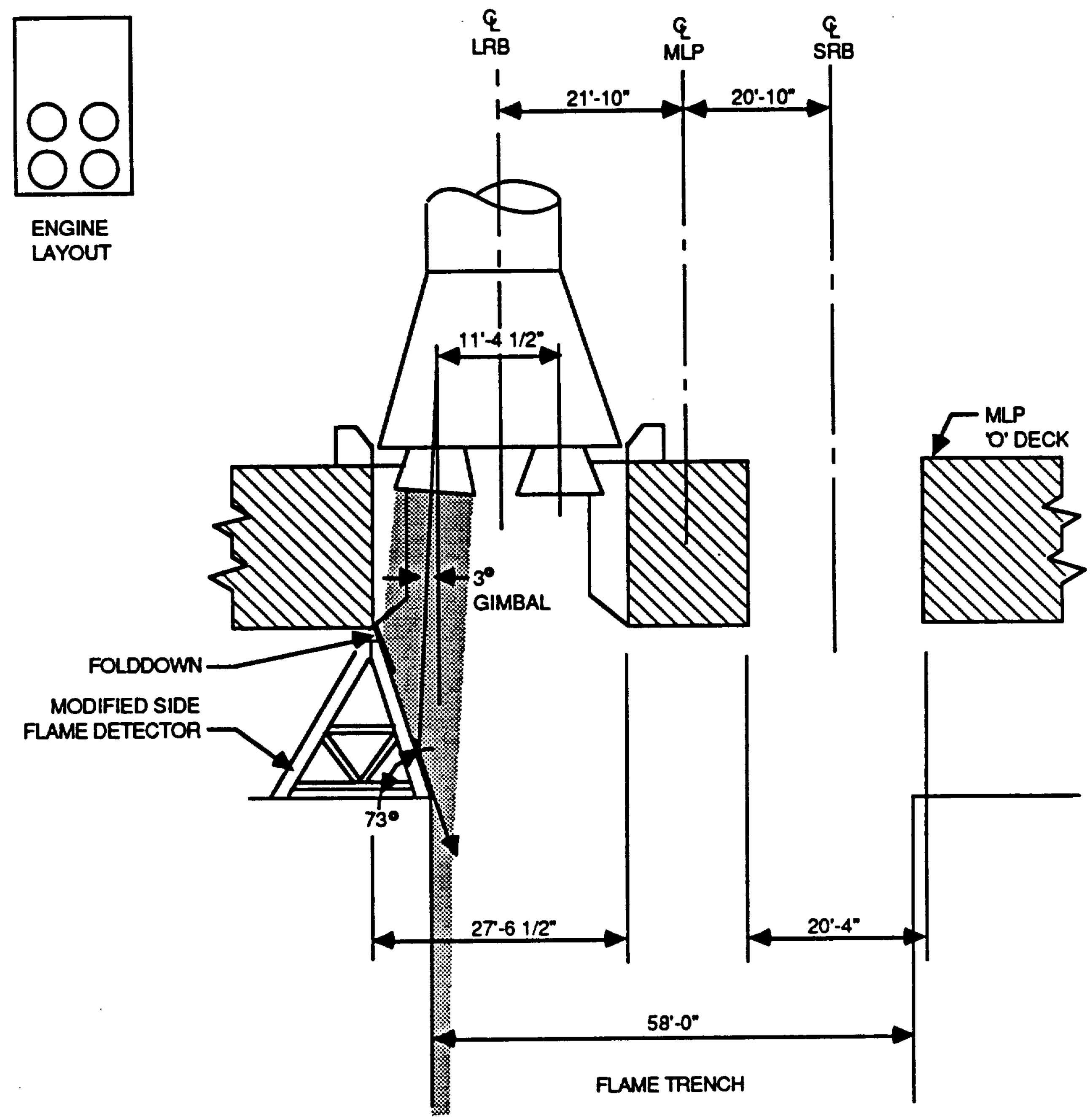


Figure 3.4.1.1-1. Side Deflector Modification for Martin Pressure-Fed LO2/RP-1 (South Elevation).



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Figure 3.4.1.1-2. Side Deflector Modification for GDSS Pump-Fed LO2/RP-1 (South Elevation).

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There are basically two LRB engine configurations; one by General Dynamics Space Systems Division and another by Martin Marietta Space Manned Systems. Each has a four-engine configuration with the basic difference between them being 90 ^{o}.

Both concepts of the LRB engines have the capability of gimballing 6 ^{o} maximum from the neutral position. This will introduce higher blast pressures on the side deflectors at maximum gimbal position.

Maximum impingement angle of the flame deflectors is dependent on the position of the LRB engines. The blast pressures introduced on the flame deflector can vary enormously. Figure 3.4.1.1-3 shows both GDSS and MMC impact concepts. All engines are shown in null positions and show area of impact on side deflectors. The blast pressures from LRB engines have shifted to the west on side deflectors on null position of engines. This will increase more if the engine gimballed east-west. At present SRB blast pressure has no direct blast pressure on side flame deflectors. The existing sound suppression system also receives direct blast pressures from LRB engines. Further evaluation and an impact study are required in the following areas:

- Foundations for the side flame deflectors
- Refractory concrete evaluation for increased duration of flame
- Acoustic study
- Sound suppression system

New folddown concept and design would be required to stop exhaust from going between the MLP and the top of the side deflectors.

Significant redesign of the side flame deflector will be required. A 6.4 scale model test and recertification for flight readiness approval of testing is required. Considerable time impacts would be expected before completion of this task.

3.4.1.2 Main Flame Deflector Impacts

The purpose of the Orbiter side of the main flame deflector is to deflect the blast pressures from the Orbiter engines away from the Shuttle and into the flame trench. It also directs the water flow from the sound suppression down to the trench. The deflector is of a structural steel construction,

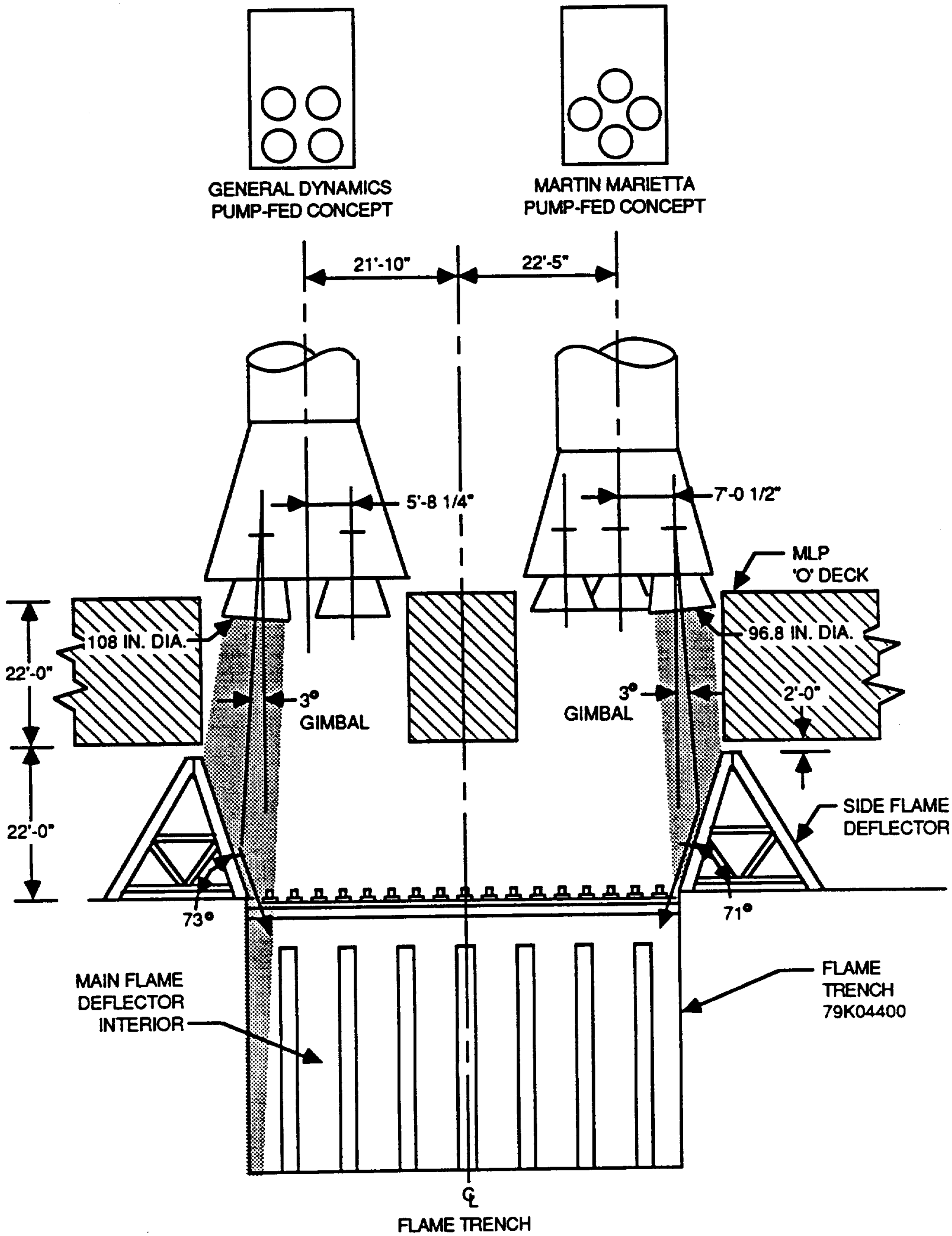


Figure 3.4.1.1-3. Pad Flame Deflectors (South Elevation).

fixed in place and covered with refractory concrete to protect the steel. It is located in the bottom of the flame trench and slopes up to the edge of the flame trench walls.

The purpose of the SRB side of the main flame deflector is to deflect the blast pressures from the SRBs away from the Shuttle and into the trench. It also directs the water from the sound suppression system down the flame deflector into the retention ponds. The SRB flame deflector is of structural steel construction and is rolled in place on top of rails located at the bottom of the flame trench. It is then attached to the Orbiter main flame deflector and concrete applied to the top to protect the steel.

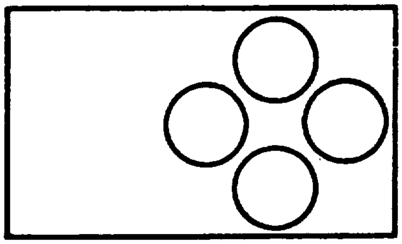
An evaluation of the existing Orbiter main engines flame deflector yielded major problems. With the configuration of the new LRB engines, the blast pressures have shifted south on the main deflector introducing a direct hit to the top of the sound suppression system. This is with the LRB engines in the null position. These pressures will increase as the LRB engines gimbal to their maximum position. A new Orbiter main engine deflector needs to be designed and positioned south of the present location to avoid the direct blast.

With the new LRB engines configuration, the blast pressures shifted south with the engines at null position giving a direct hit to the top of SRB flame deflector. When the engines gimbal, these pressures will increase depending on the gimballing position.

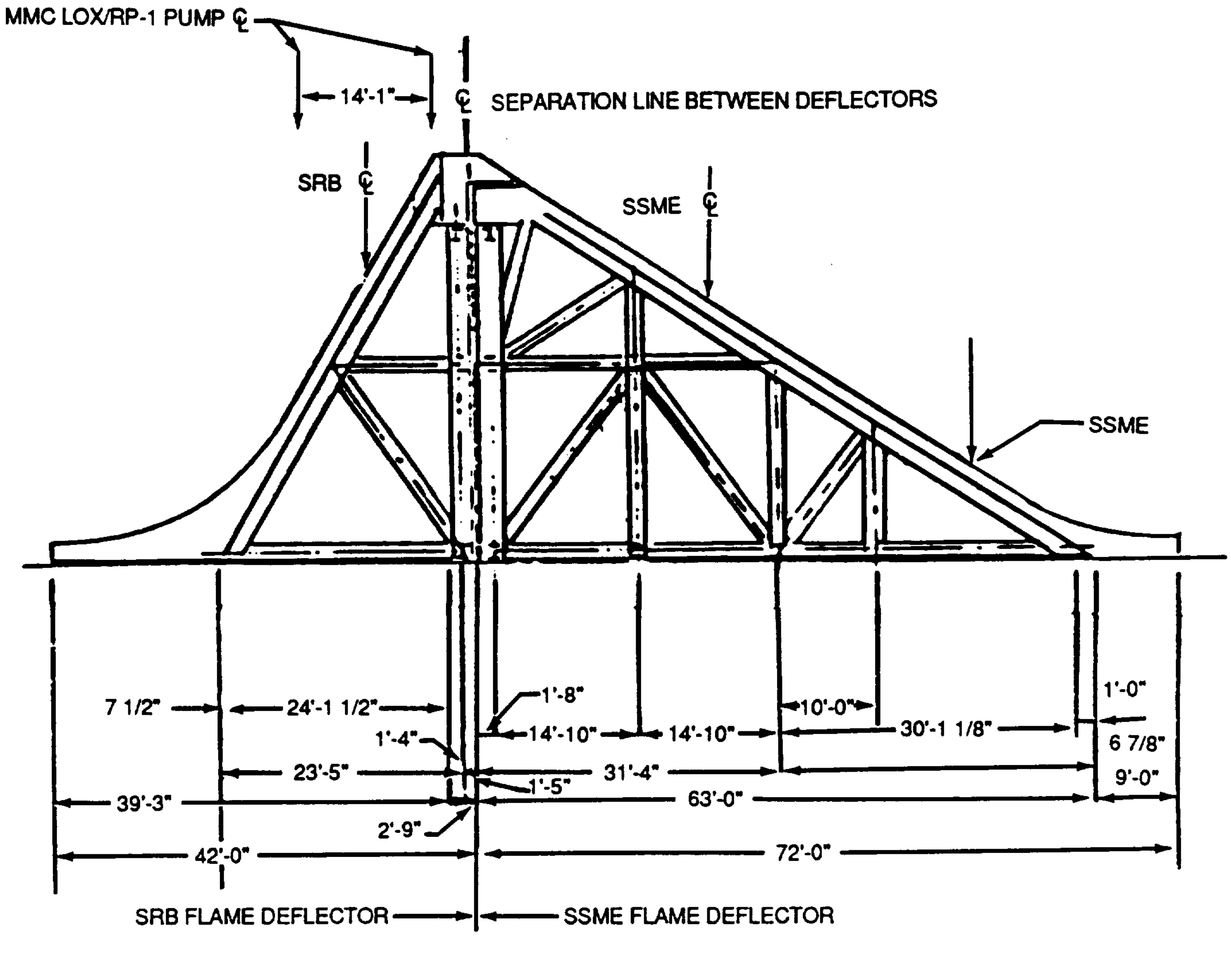
Figure 3.4.1.2-1 shows MMC LOX/RP-1 pump-fed engine configuration and centerline of engines blast (approximately) impacting on flame deflector. If an engine gimbals toward the south, the LRB engine exhaust will be on the SSME side. In order to have engine gimballing capability toward south and cut off LRB engine exhaust, the centerline between deflector (called appex) must be moved further south; i.e., redesign of flame deflectors would be required.

3.4.1.2.1 Design Options

Option 1 - New Design Single Deflector - Figures 3.4.1.2-2 and 3.4.1.2-3 show flame deflector concepts that will have dual capabilities (SRB and LRB) for launch. The flame deflectors will have mechanically pneumatic arrangements to shift location of appex for SRB and LRB launch (appex location 1 to 2).

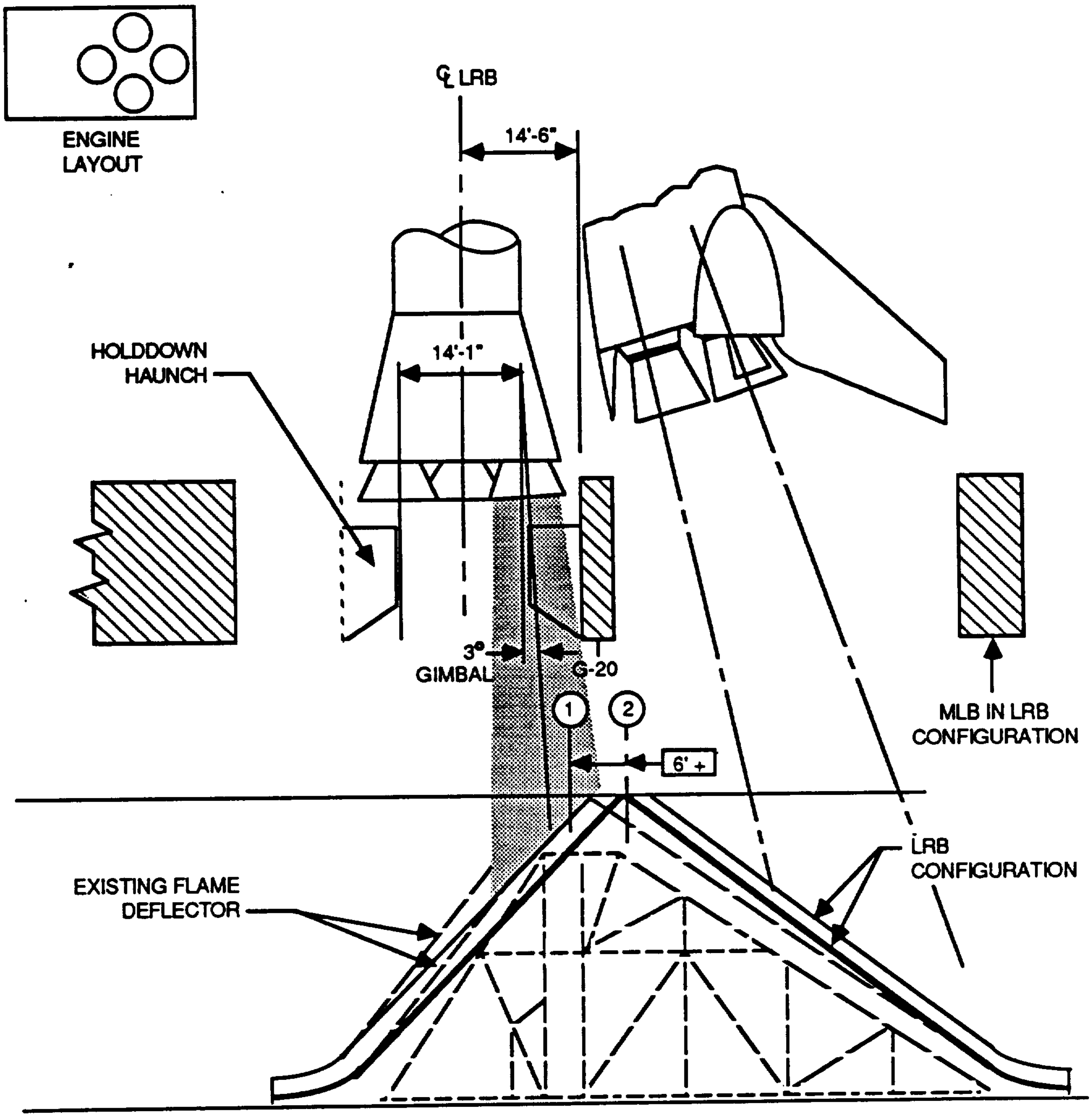


ENGINE LAYOUT



IMPINGEMENT LOADS
ON EXISTING FLAME DEFLECTOR

Figure 3.4.1.2-1. Pad Main Flame Deflector Engine Blast for MMC LOX/RP-1 Pump-Fed.



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Figure 3.4.1.2-2. Dual Capability Flame Deflector for Martin Concepts (Pump).

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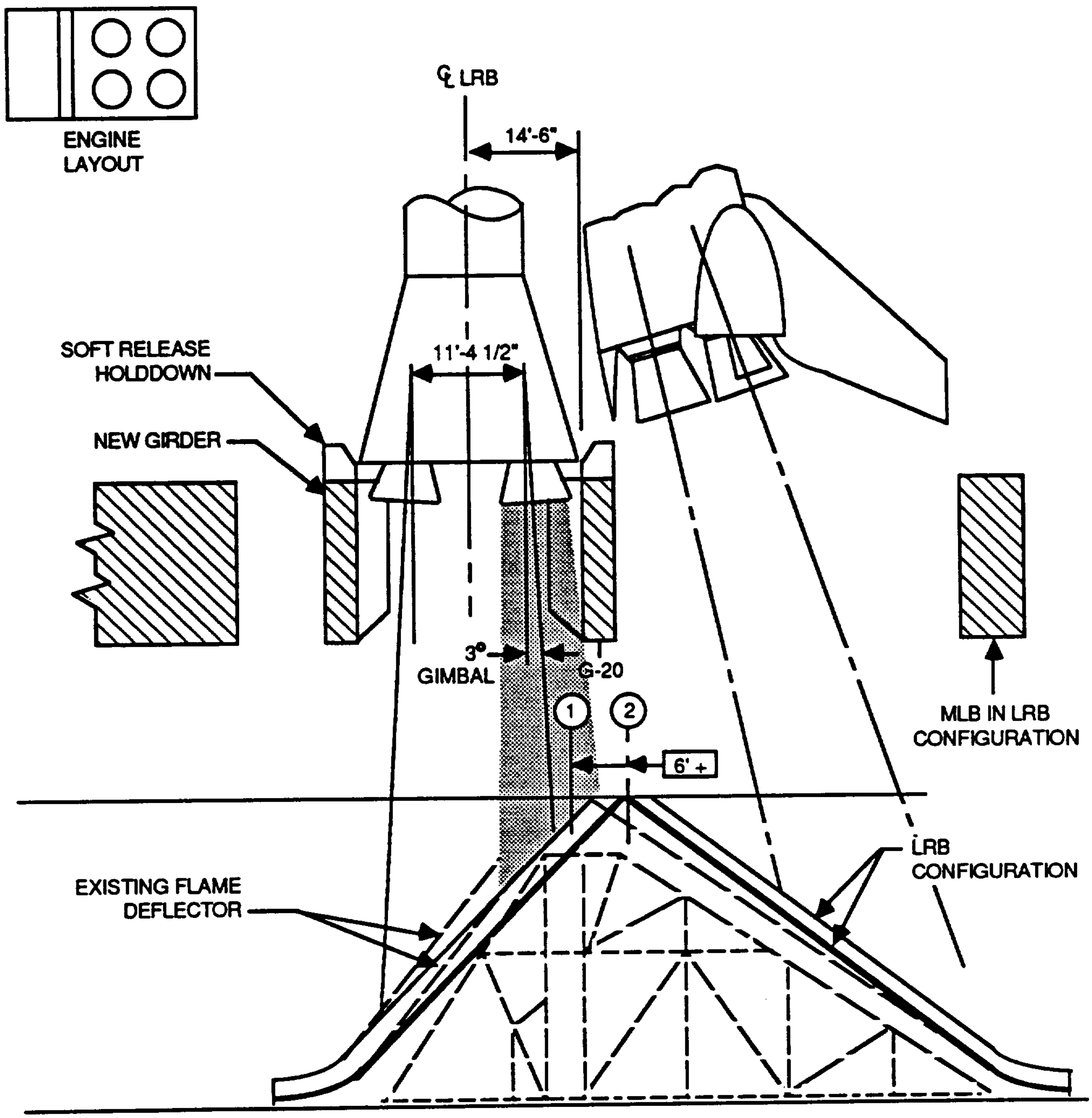


Figure 3.4.1.2-3. Dual Capability Flame Deflector for GDSS Concept (Pump).

Option 2 - Individual Sets for SRB and LRB - This option will have separate sets of flame deflectors per SRB launch and LRB launch. Towing in and out of flame trench and installation will be required. Existing weight of flame deflectors is tabulated in Figure 3.4.1.2-4. It will be very difficult to move these structures around.

3.4.1.2.2 Conclusions and Recommendations:

Since handling, towing, and installing of main flame deflectors will constitute a major effort and storing two sets of flame deflectors will require a lot of space at the pads, providing a dual capability deflector is recommended. Although building of the flame deflectors will have to be away from pads, this will require some assembly at the pads.

3.4.1.2.3 Applicable Documents and References

Flame Trench and Main Flame Deflectors - 79K04400
Standard for Flame Deflector Design - KSC-STD-Z-0012

3.4.2 Access Requirements

This section provides an evaluation of the present Pad access platforms to determine the requirements to launch a Shuttle with either SRBs or LRBs.

The study used the MMC LOX/RP-1 pump-fed concept as the basis for its evaluation.

3.4.2.1 Orbiter/ET/SRB Access Requirements

Orbiter Access - Vehicle access platforms are provided at 191 ft, 173 ft, 158 ft, and 125 ft elevation on Pad B (similar levels on Pad A are 5 ft lower) to service the antenna, Orbital Maneuvering Subsystem (OMS) pod, and Auxiliary Power Unit (APU). (See figure 3.4.2.1-1.)

ET Access - Access to the ET is provided by a set of platforms that travel on tracks on the Payload Checkout Room (PCR) side. Access range is from the FRCS room to the roof (212 ft to 156 ft.). See Figure 3.4.2.1-2. (Similar access platform is provided on Pad A.)

APPROXIMATE WEIGHTS OF EXISTING FLAME DEFLECTORS		
MAIN FLAME DEFLECTOR SRB FLAME DEFLECTOR	STEEL REFRACTORY CONC.	1,150,000 LBS. 261,000 LBS
SSME FLAME DEFLECTOR	STEEL REFRACTORY CONC.	1,130,000 LBS 371,000 LBS
SIDE FLAME DEFLECTOR (EACH) (2 REQUIRED)	STEEL REFRACTORY CONC.	250,000 LBS 75,000 LBS

Figure 3.4.1.2-4. Weight of Separate Flame Deflectors for LRB and SRB.

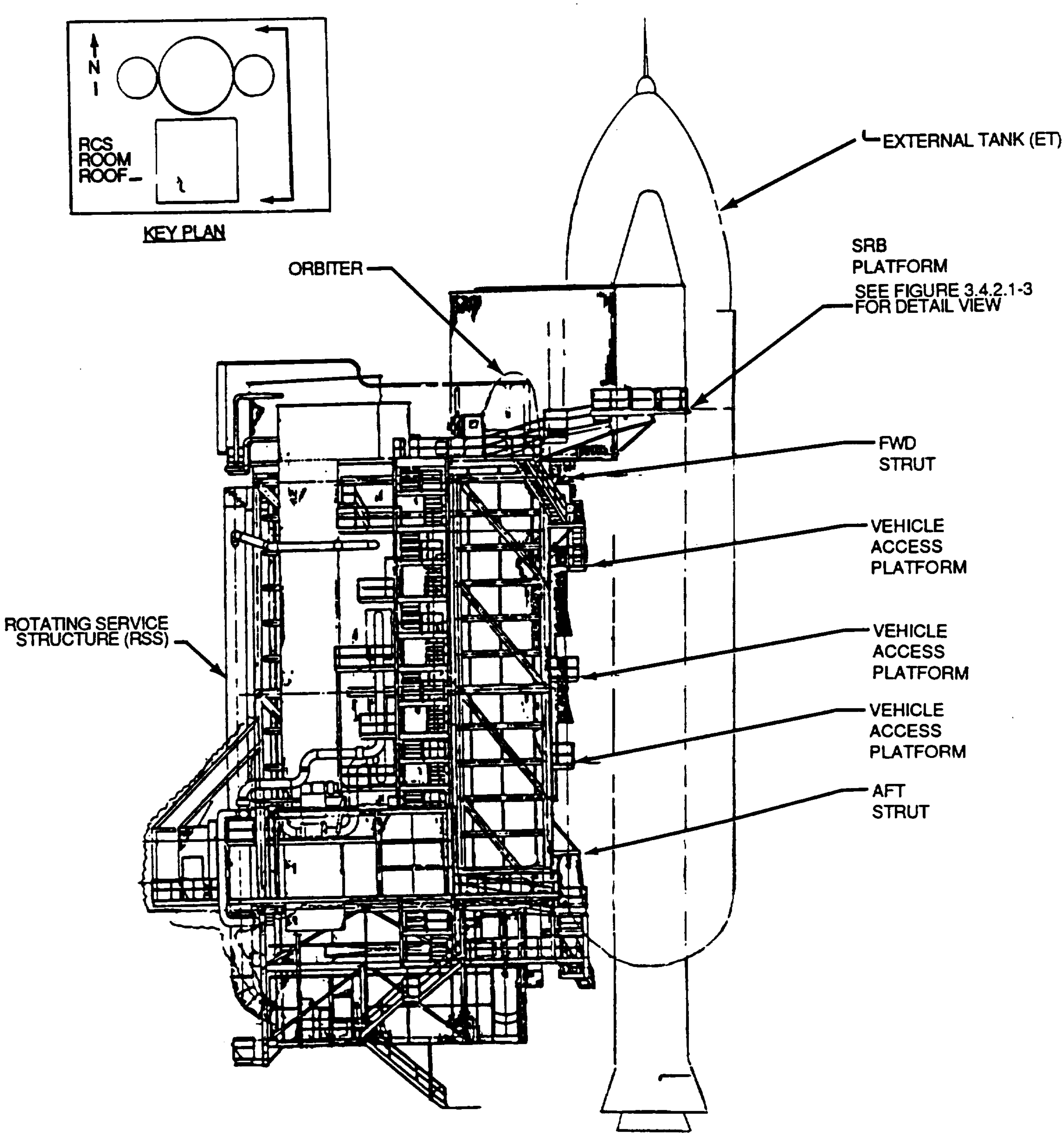


Figure 3.4.2.1-1. SRB/Orbiter Access Platforms.

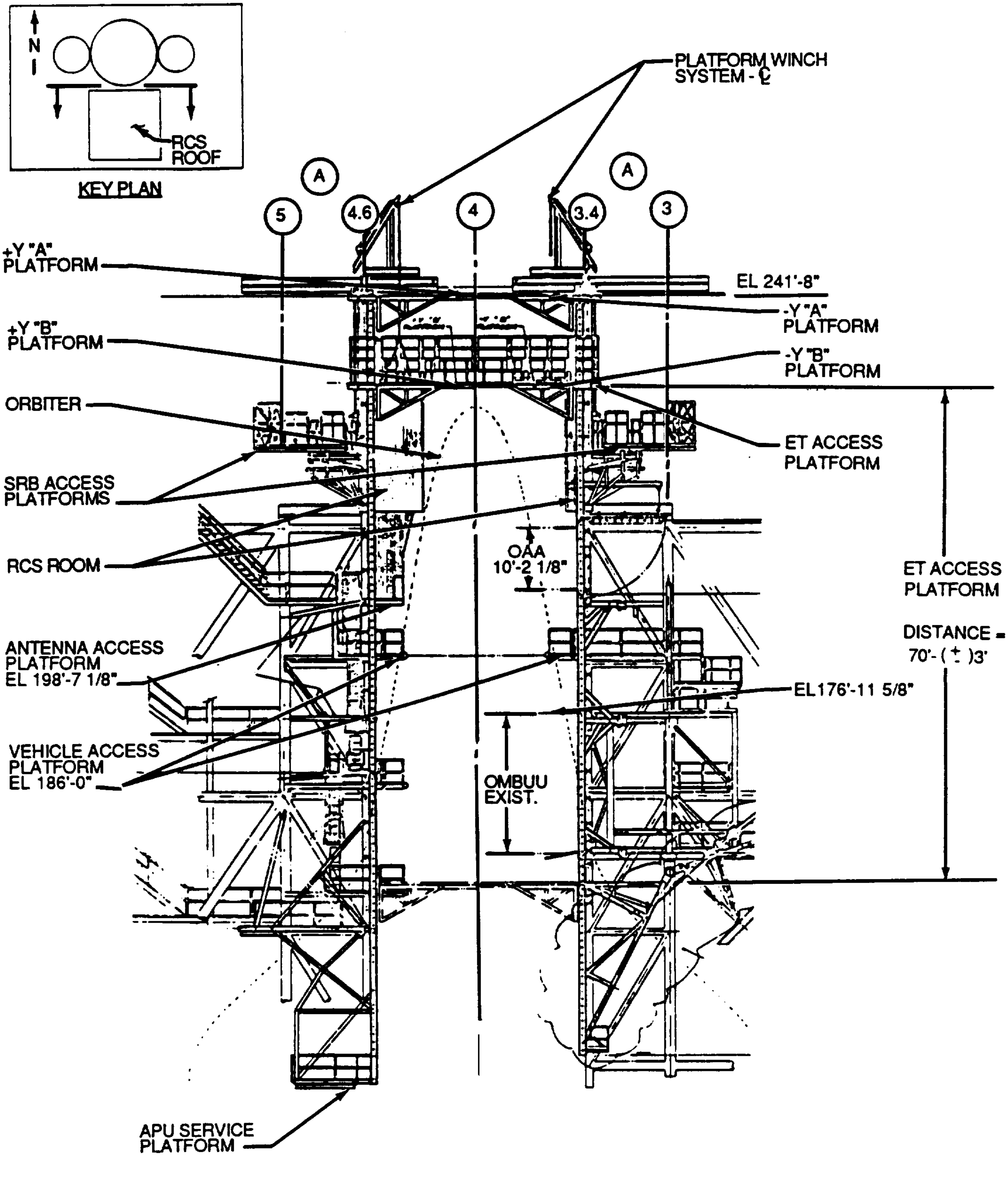


Figure 3.4.2.1-2. ET Access Platforms.

SRB Access - Access platform for the SRB nose cone (forward access) is shown in Figure 3.4.2.1-1. Access to the forward and aft strut areas is provided from the RSS side. Figure 3.4.2.1-3 shows the detailed side elevation of the SRB access platform and the Orbiter access area. It also shows forward and aft ET/Orbiter attach points.

3.4.2.2 LRB Access Requirements

Figure 3.4.2.2-1 illustrates an overall arrangement of LRB/Orbiter and SRB/Orbiter dual capability access platforms.

Intertank Access - Figure 3.4.2.2-2 lists the locations of the LRB intertank areas. The access requirements for the MMC LOX/RP-1 pump-fed concept is approximately 55 ft above the "0" deck level of the MLP. This access could be achieved by providing a movable platform from the existing Orbiter weather protection. (See Figure 3.4.2.2-3.) Additional catwalks or platforms would be required to gain access from the FSS. A further study is required for the intertank access requirements of the MMC LOX/RP-1 pressure-fed and the LOX/RP-1 pump-fed and GDSS concepts. Their locations would require additional support structures. The existing ET/Orbiter access platforms (Figure 3.4.2.2-4) can be used for intertank access of the taller boosters if the hatch is located appropriately.

Forward (Nose Cone) Area Access - This area is about the same level as for SRB forward area access. With some modifications to the existing platform, access to the forward area for LRB can be achieved. This is good for MMC LOX/RP-1 pump-fed concept. A similar problem like access to the intertank exists for MMC LOX/RP-1 pressure-fed and GDSS concepts. There is no existing structures to support access. A further study will be required. This study would examine the possibility of adding structural members from FSS/RSS structures to come up with solving access problems. A proposed concept is shown in Figure 3.4.2.2-4. This concept requires in-depth analysis and design.

3.4.2.3 Conclusions

Orbiter Access - There would be no impact on these platforms with the introduction of LRBs since the access requirements would remain the same.

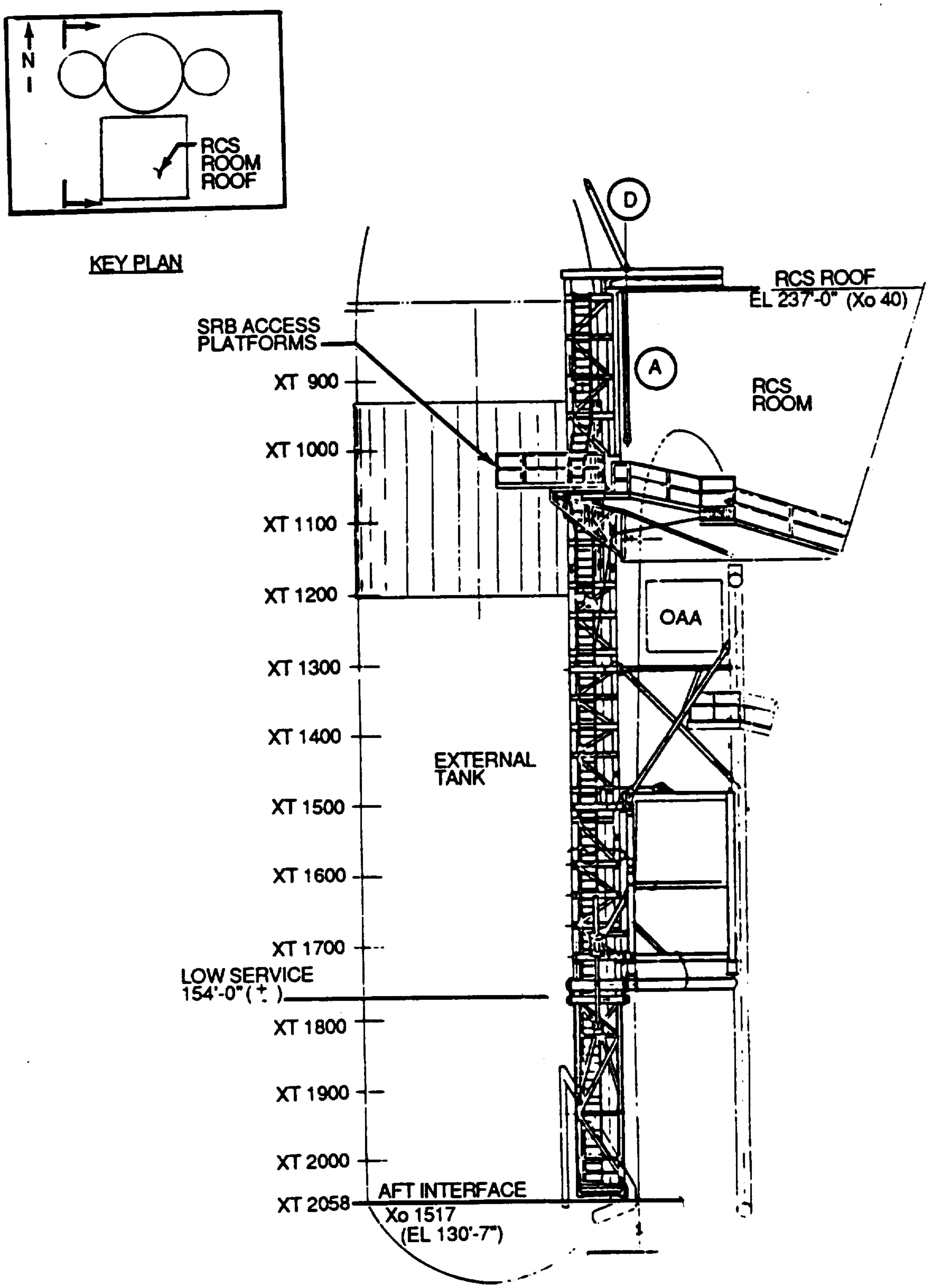


Figure 3.4.2.1-3. SRB/ Orbiter Access Platform (SRB and RSS Not Shown).

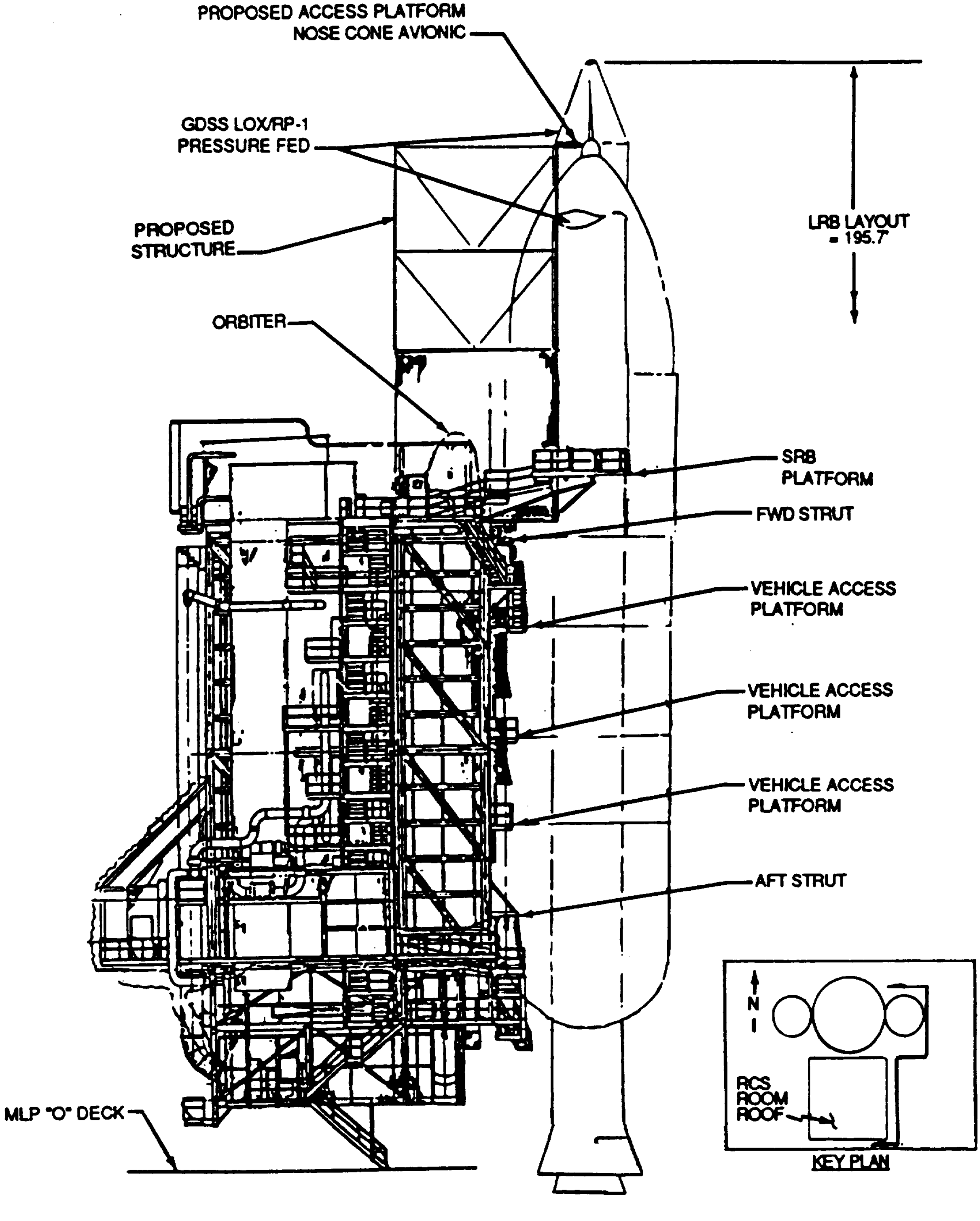


Figure 3.4.2.2-1. Access Requirements for LRB/SRB/Orbiter.

LRB ACCESS REQUIREMENTS							
	MMC		GDSS				
	LOX/RP-1 PUMP-FED	LOX/RP-1 PRESSURE-FED	LOX/RP-1 PUMP-FED	LOX/RP-1 PRESSURE-FED	LOX/CH4	LOX/LH2	LO2/LH2 FATBIRD
BOOSTER DIAMETER	15.3'	16.2'	14.1'	15.0'	15.0'	16.2'	17.7'
HT	150.9'	162.7'	148.8'	195.7'	150.1'	191.0'	169.5'
ENGINE LEVEL ACCESS (REF: MLP '0' DECK)	MLP '0'	MLP '0'	MLP '0'	MLP '0'	MLP '0'	MLP '0'	MLP '0'
'NTERTANK AREA .L. ABOVE MLP '0' DECK)	56.7'	60.3'	59.2'	81.6'	65.4'	125.3'	111.8'
FWD. AREA (EL. ABOVE MLP '0' DECK)	126.0'	130.7'	126.8'	173.3'	126.7'	165.4'	144.0'

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Figure 3.4.2.2-2. LRB Access Requirements.

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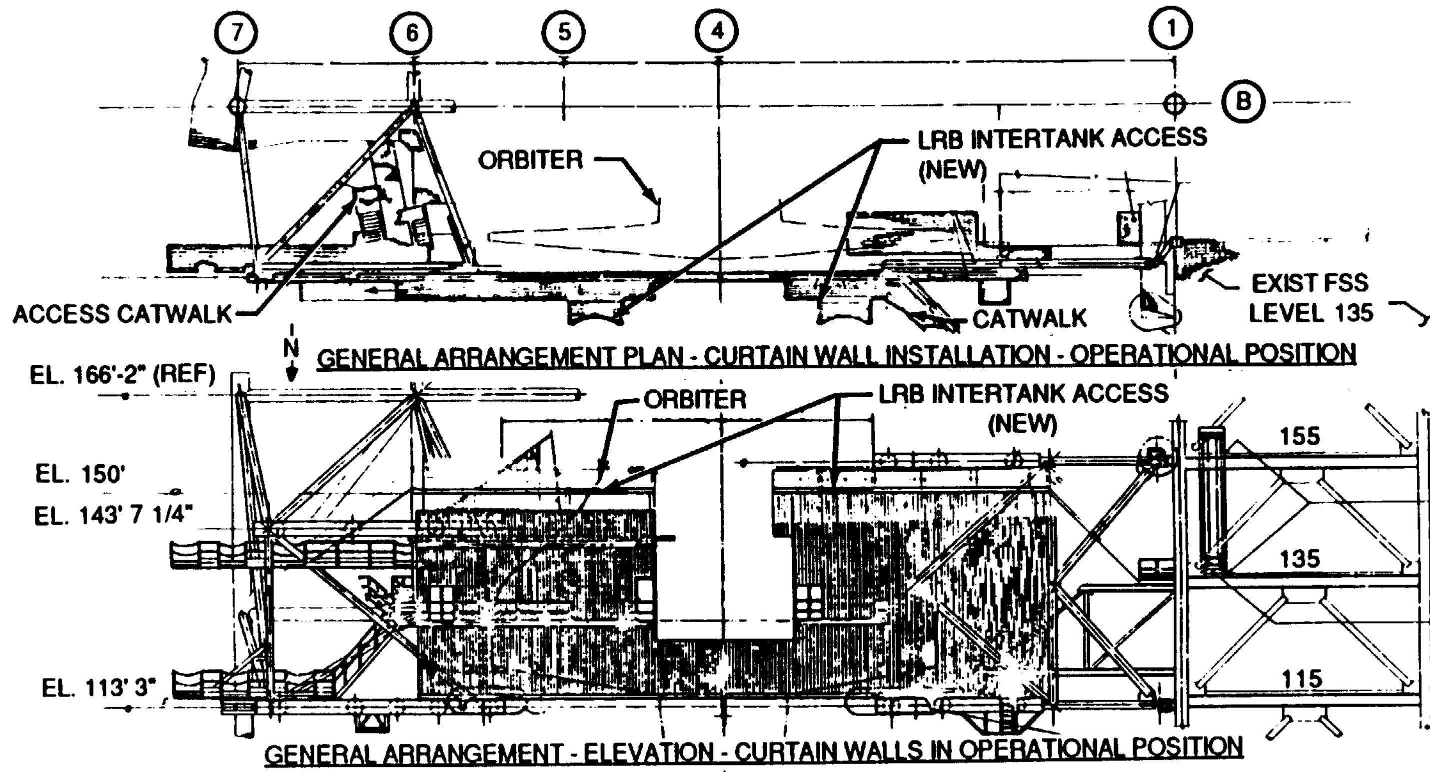


Figure 3.4.2.2-3. LRB Intertank Platforms at Pad.

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3-3.4.2 11/8 1:00p

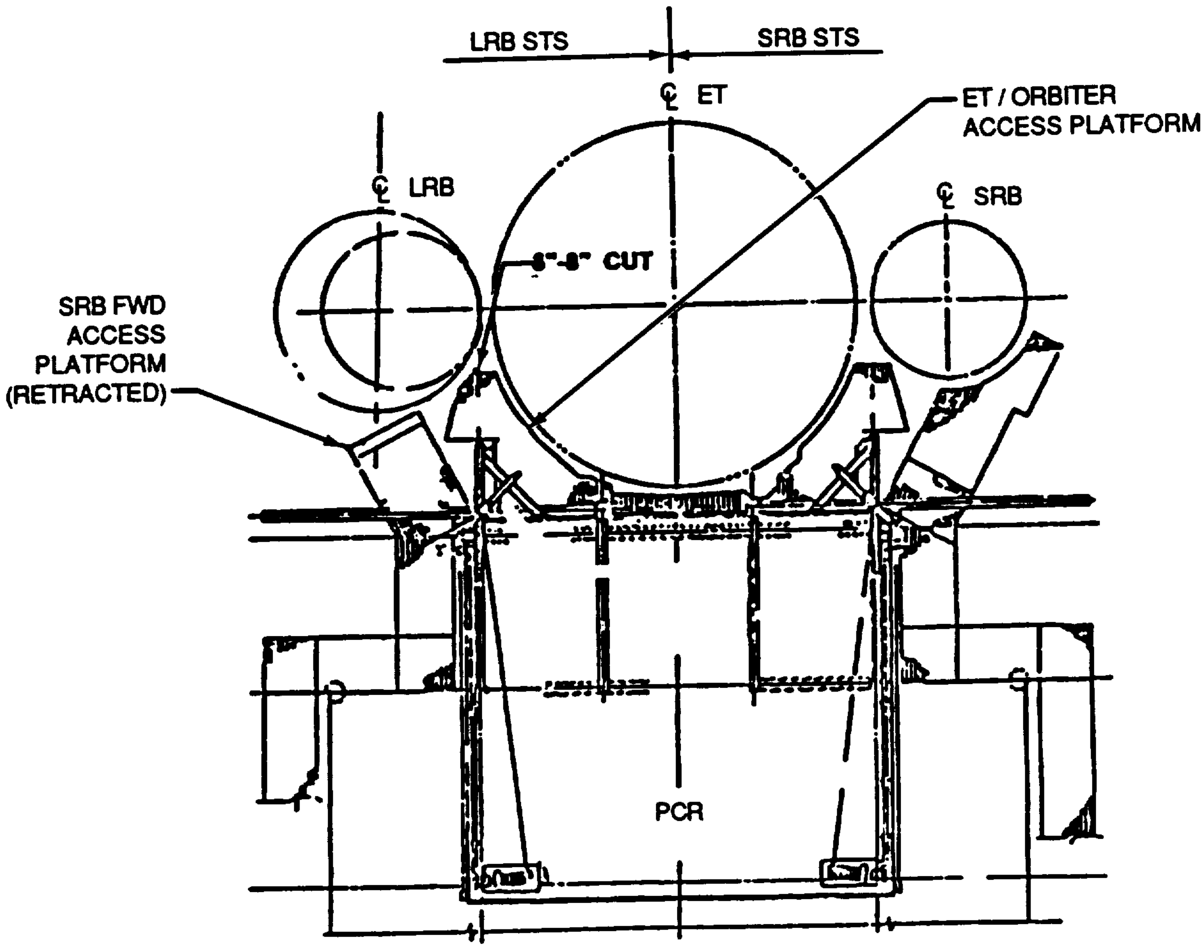


Figure 3.4.2.2-4. Launch Pad Access Platforms.

External Tank - Modification to the existing platforms would be required.

SRB Access - The existing platforms could be used with minor modifications.

3.4.2.4 References

Pad A 79K04400

Pad B 79K14110

Orbiter Weather Protection: Pad A - 79K24556

Orbiter Weather Protection: Pad B - 80K51416

3.4.3 Orbiter/ET Umbilical Impacts

This section describes the impact to existing LC-39 umbilicals and swing arms that would result from a conversion from SRBs to LRBs in the Space Shuttle program.

3.4.3.1 Description of Present Umbilicals/Swing Arms

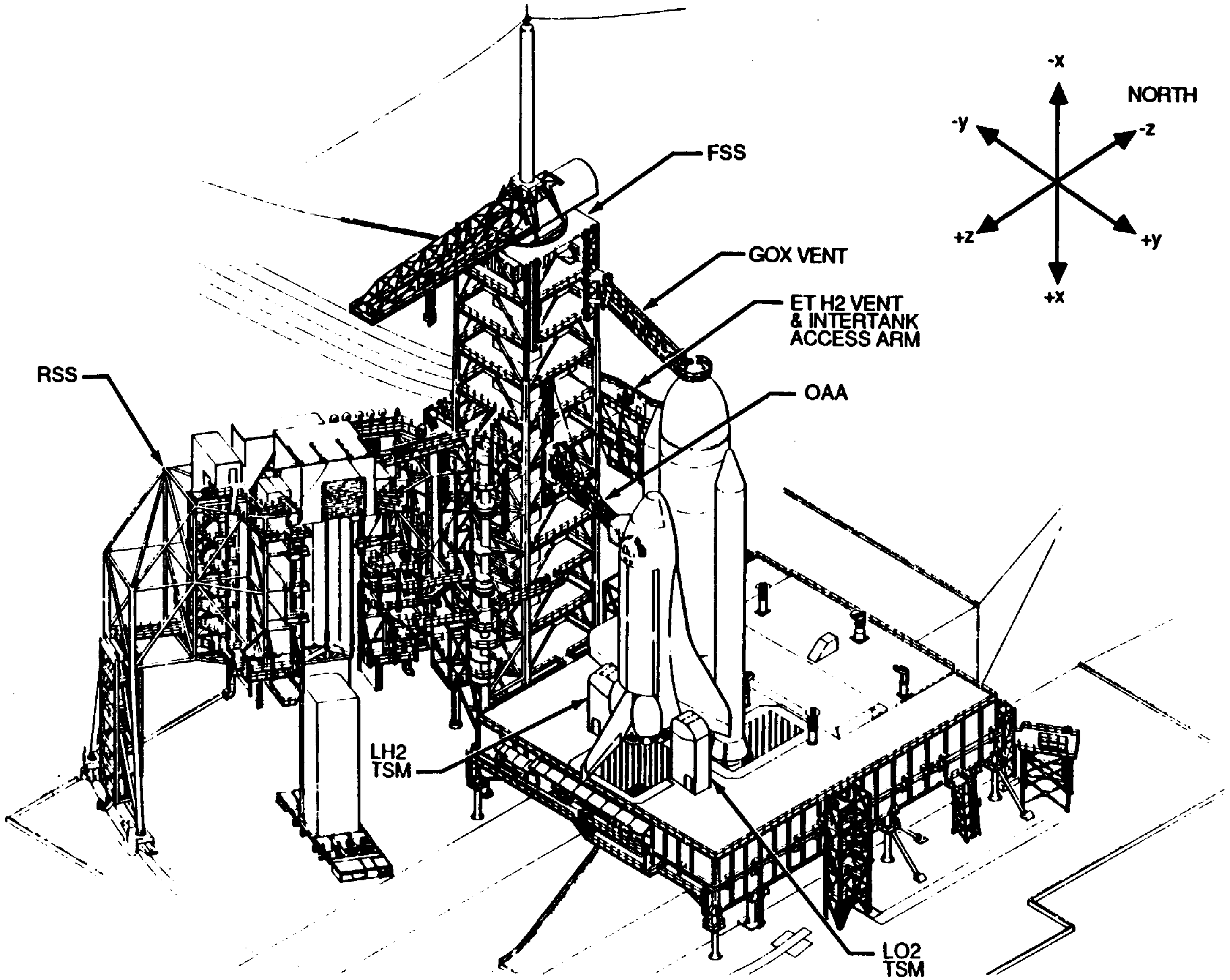
Five major umbilicals and three swing arms are required to service an SRB-configured Shuttle System at the launch pad. Of these, all but the SRB joint heater umbilicals will still be required for an LRB-equipped Shuttle. Following is a brief description of the five remaining umbilicals and three swing arms which must be evaluated for LRB compatibility.

3.4.3.1.1 Swing Arms

The swing arms include the GOX vent Orbiter access arm and ET intertank vent arm.

GOX Vent - Consists of a cantilevered truss arm which is pivoted at the FSS (Figure 3.4.3.1-1). At the forward end of the arm is the GOX Hood Assembly, which mates with the tip of the ET and functions to transport GO2 away from the vehicle and prevent ice formation during venting. The GOX vent provides service during tanking operations and is rotated clear of the vehicle several minutes before launch.

Orbiter Access Arm (OAA) - Supports a clean room, allowing access to the Orbiter crew compartment (Figure 3.4.3.1-1). The arm pivots at the FSS and is rotated away from the vehicle approximately 7 minutes before launch.



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Figure 3.4.3.1-1. Pad Swing Arms and Umbilicals General Arrangement.

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ET Intertank Access Arm - Attaches to the ET vent support structure (Figures 3.4.3.1-1 and 3.4.3.1-2). When rotated forward it allows access to the ET intertank and processing of the ET vent umbilical. The arm is typically retracted 5 days before launch.

3.4.3.1.2 Umbilicals

The three umbilicals include the Orbiter mid-body umbilicals unit, hypergol Umbilicals, and ET H2 vent.

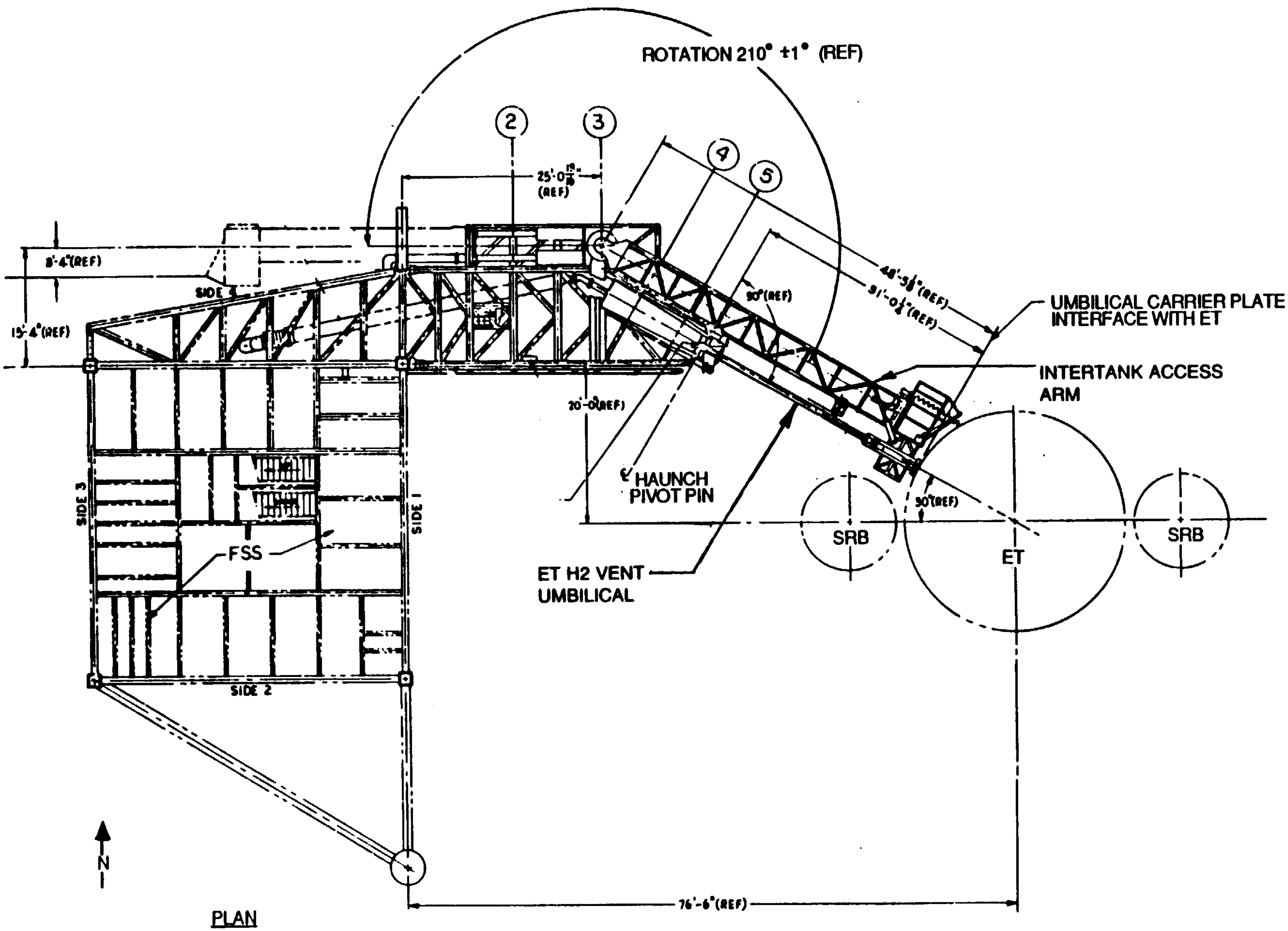
Orbiter Midbody Umbilical Unit (OMBUU) - Located on the RSS (Figures 3.4.3.1-3 and 3.4.3.1-4), it connects to the west side of the Orbiter for fluid and electrical service. The umbilical is disconnected prior to RSS rollback.

Hypergol Umbilicals - Located below the Payload Changeout Room on the RSS (Figure 3.4.3.1-3). One umbilical is connected to the aft of each Orbital Maneuvering Subsystem (OMS)/Reaction Control System (RCS) pod for hypergol servicing. The umbilicals are disconnected prior to RSS rollback.

ET H2 Vent - Attached to the ET in the intertank area (Figure 3.4.3.1-2), its primary function is to transfer hydrogen gas away from the vehicle during venting. The umbilical is attached to the ET shortly after pad rollout and remains attached until SRB ignition. At ignition the umbilical disconnects from the vehicle, drops away, and secures clear of the flight path.

3.4.3.2 Assumptions/Exclusions

Existing Orbiter and ET ground interfaces will remain at current position relative to LC-39. Number and size of connections across existing Orbiter and ET ground interfaces will not change significantly. Although it is assumed for the purpose of this study that the vehicle excursions will not change, the impact of an increase should be considered. A significant increase in vehicle excursions could affect all the existing systems requiring hardware modifications and require LETF testing. Two systems in particular, the GOX Vent and TSMs, currently have very little capability for excursion growth without hardware modification. Also, the ET Vent and OAA have limited capability for excursion increases. Although Vehicle launch drifts will change due to a decrease in the thrust-to-weight ratio and blast loads will change they are not addressed. This is due to a lack of data expected from the phase A LRB contracts.



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Figure 3.4.3.1-2. ET Hydrogen Vent System.

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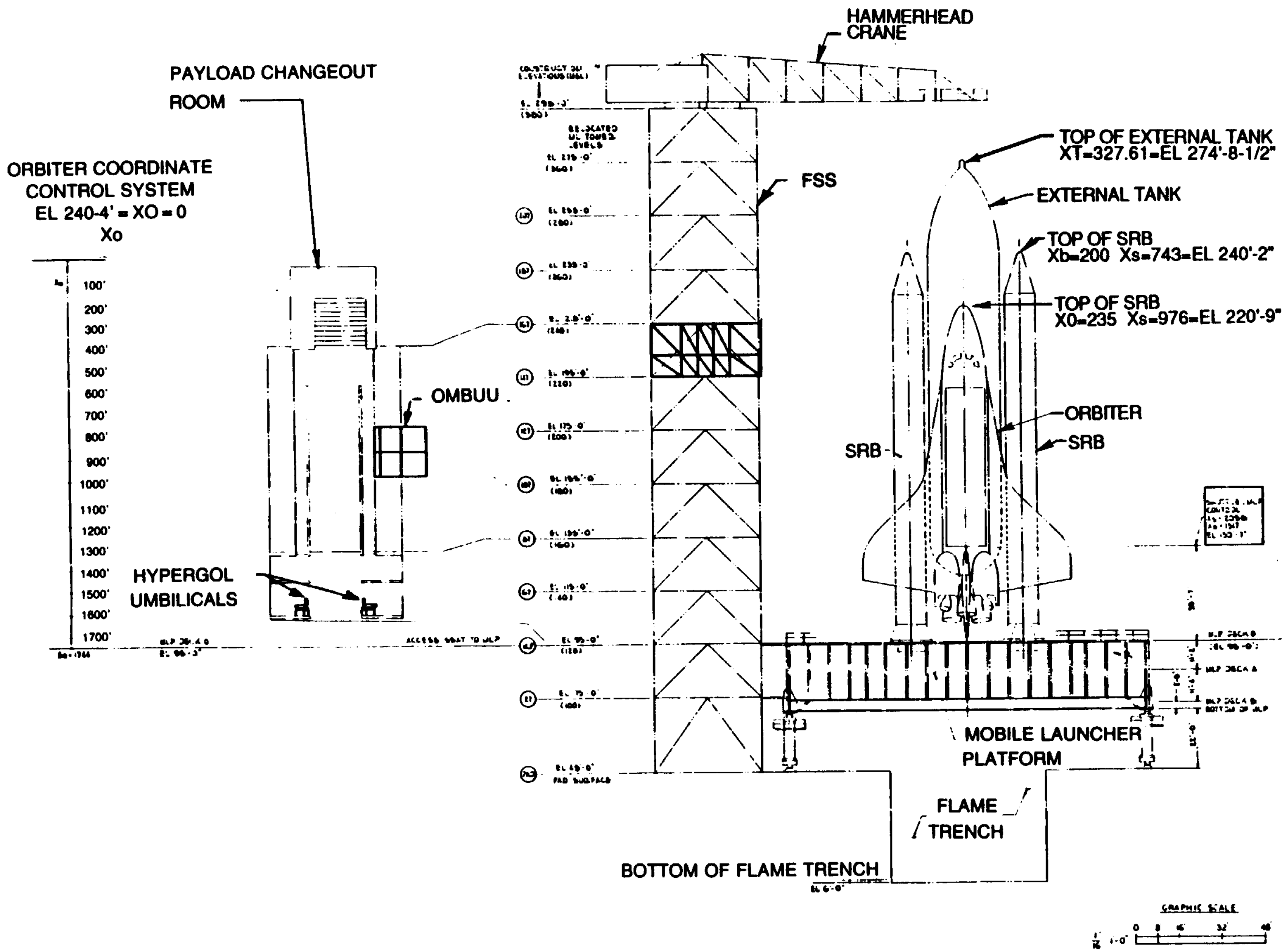


Figure 3.4.3.1-3. OMBUU Elevation.

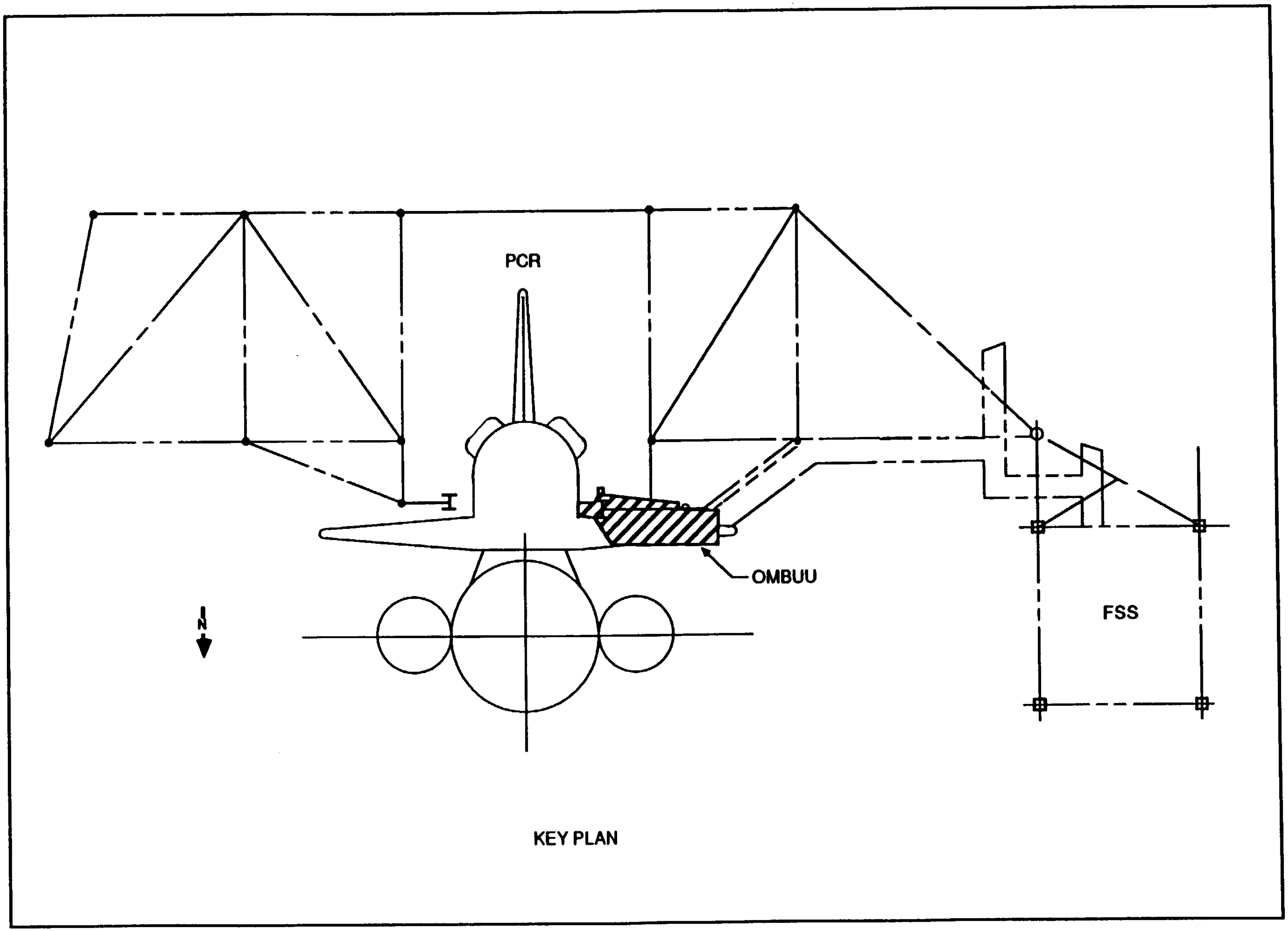


Figure 3.4.3.1-4 OMBUU Plan.

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3.4.3.3 Compatibility Concerns

Based on the assumptions of this study, the primary concern for LRB compatibility is that LRBs have sufficient clearance for all prelaunch conditions. Ground systems must clear LRBs during disconnect and retraction. The LRBs must clear systems for worst case launch drifts. Figure 3.4.3.3 lists the LRB concepts and associated dimensions used for this study.

3.4.3.4 LRB Compatibility With Each Swing Arm

3.4.3.4.1 GOX Vent Arm

This system would be unaffected by the diameter increases for any of the six LRB concepts; however, LRB lengths over 170 ft have hard interference with the existing structure. As shown in Figure 3.4.3.4-1, both the GDSS RP-1 and LH2 LRBs are incompatible with the current GOX vent.

To increase the GOX venting capability necessitated by the longer LRBs, it would be necessary to place the vent arm alongside the booster rather than over it, as in the existing design. As shown in Figure 3.4.3.4-2, for a GDSS-LO2/LH2 LRB to obtain a 2-ft clearance, it would be necessary to place the vent arm at 45 degrees to the booster centerline. The arm could be projected north or south of the vehicle, with the north being chosen to place the pivot closer to the existing position, thereby simplifying routing of fluid and electrical service lines.

Also shown in Figure 3.4.3.4-2 is the location of the pivot point if the entire existing GOX vent arm were placed at the required 45-degree angle. This is a possible alternative to the concept presented, but it is considered less favorable due to the extensive structural additions which would have to be made to the FSS.

The concept presented in Figure 3.4.3.4-2 will use as much of the existing arm and associated components as possible, but it would require a new or modified hood assembly, a new aft arm segment, new hinge and hinge actuating mechanism, and structural additions to the FSS. Additionally, a modification of this magnitude would almost certainly require Launch Equipment Test Facility (LETF) requalification.

Vehicle drift clearances are not a concern for any of the six LRB concepts.

LRB	O.D.	SKIRT O.D.	LENGTH
GDSS-LOX/RP-1 PUMP	14'-1"	25.93'	149.47'
GDSS-LOX/RP-1 PRESS	15'-0"	26.8'	199.5'
GDSS-LOX/LH2 PUMP	16'-2"	22.26'	199.44'
GDSS-LOX/CH4 PUMP	15'-0"	27.27'	150.47'
MM-LOX/RP-1 PUMP	15.33'	22.1'	151.0'
MM-LOX/RP-1 PRESS	16.17'	23.3'	162.6'

Figure 3.4.3.3. LRB Concepts And Associated Dimensions.

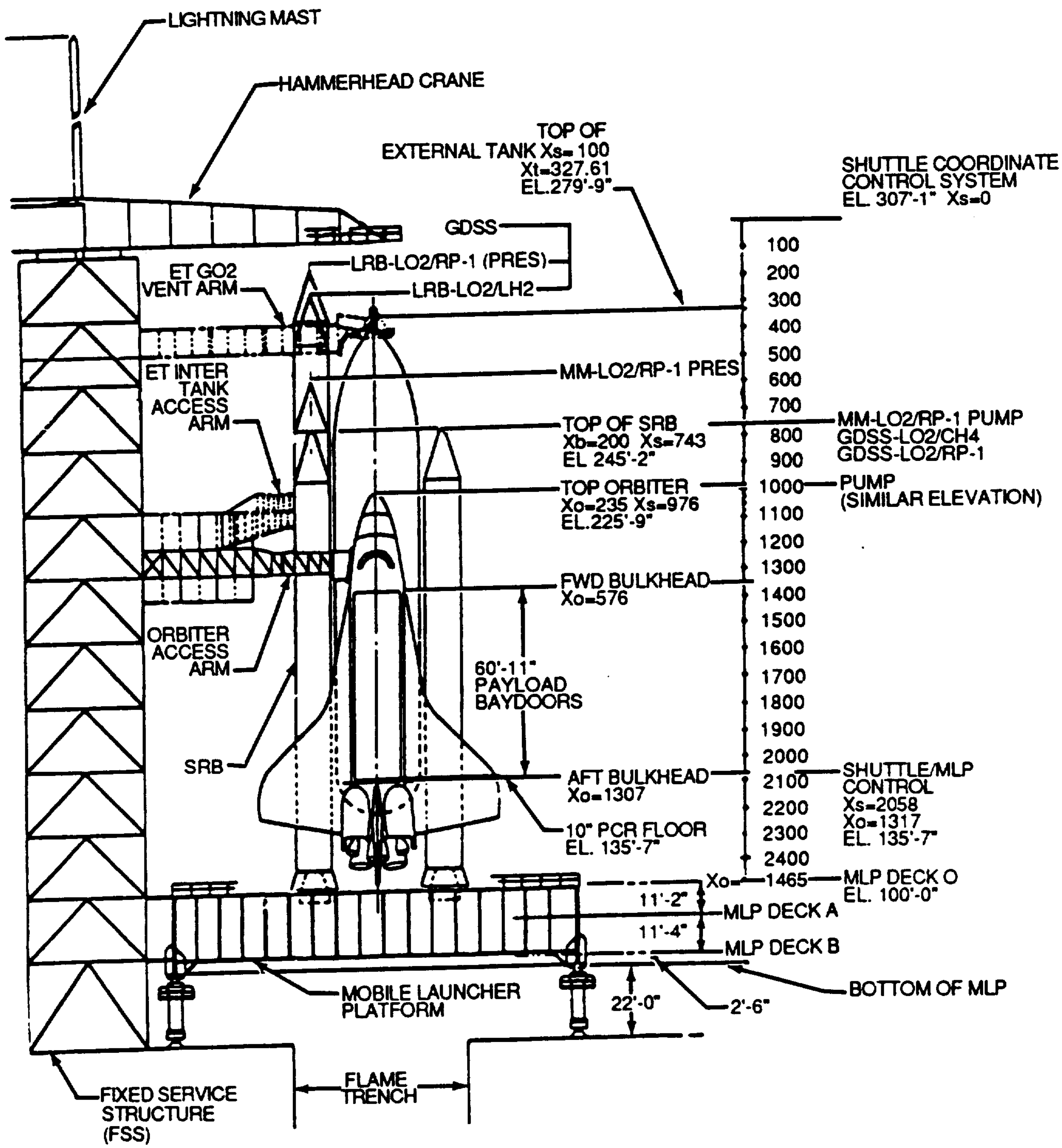


Figure 3.4.3.4-1. Pad Umbilical Systems.

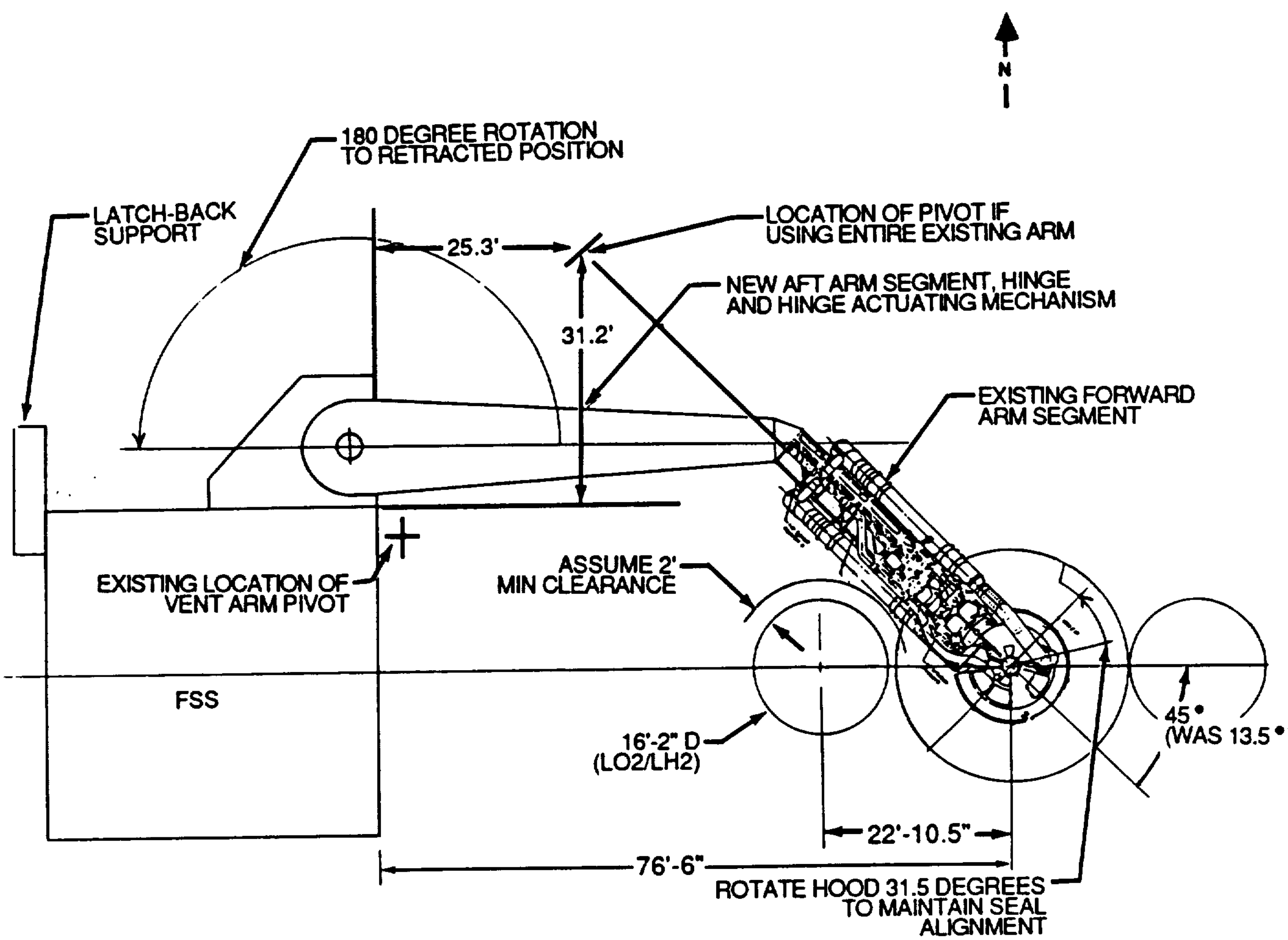


Figure 3.4.3.4-2. GOX Vent for GDSS LO2/LH2 (shown) or GDSS LO2/RP-1 (Pres) (Similar).

3.4.3.4.2 Orbiter Access Arm

When the arm is fully extended there is still clearance of over ll feet to the closest SRB. For this reason there are no clearance concerns for any of the LRB concepts in this study.

3.4.3.4.3 ET Intertank Access Arm

When extended, this arm is approximately 7 ft away from the closest SRB. Based on this observation, none of the LRBs in this study present a clearance concern for this system.

3.4.3.5 LRB Compatibility With Umbilicals

3.4.3.5.1 Orbiter Midbody Umbilical Unit (OMBUU) And Hypergol

These umbilicals service the Orbiter and are not in close proximity to the boosters. Because of this, none of the LRB concepts present a clearance problem for these systems.

3.4.3.5.2 ET H2 Vent

There are two major areas of concern for LRB compatibility with this umbilical. The first and most significant concern deals with vehicle drift clearance to the ET Vent support structure. Figure 3.4.3.5-1 from ICD-2-0A002 shows an SRB drift path past the ET vent. As noted, the minimum clearance occurs as the skirt passes the 222-ft 6.5-in level. Figure 3.4.3.5-2 shows a plan view of the SRB skirt to structure clearance at the 222-ft 6.5-in level. Note the minimum clearance is 2.7 ft.

Assuming a similar drift for the LRBs and imputing the larger skirt diameters, the structure-to-vehicle relationship is shown in Figure 3.4.3.5-3. Note that all the LRB concepts show interference at the 222-ft 6.5-in level. Unless the drifts could be modified to obtain clearance, it would be necessary to relocate the ET vent structure as shown in Figure 3.4.3.5-4. But relocating the structure would obviously produce some major system impacts. First, since the ET intertank accessarm is mounted on the structure, it would have to be lengthened to reach the ET. Also, the distance the structure is moved would require additional umbilical vent lines. And lengthening the vent line would necessitate modifying the lower level of the ET vent structure and deceleration unit, since the vent line would extend lower while in the retracted position. (Vent line is vertical when

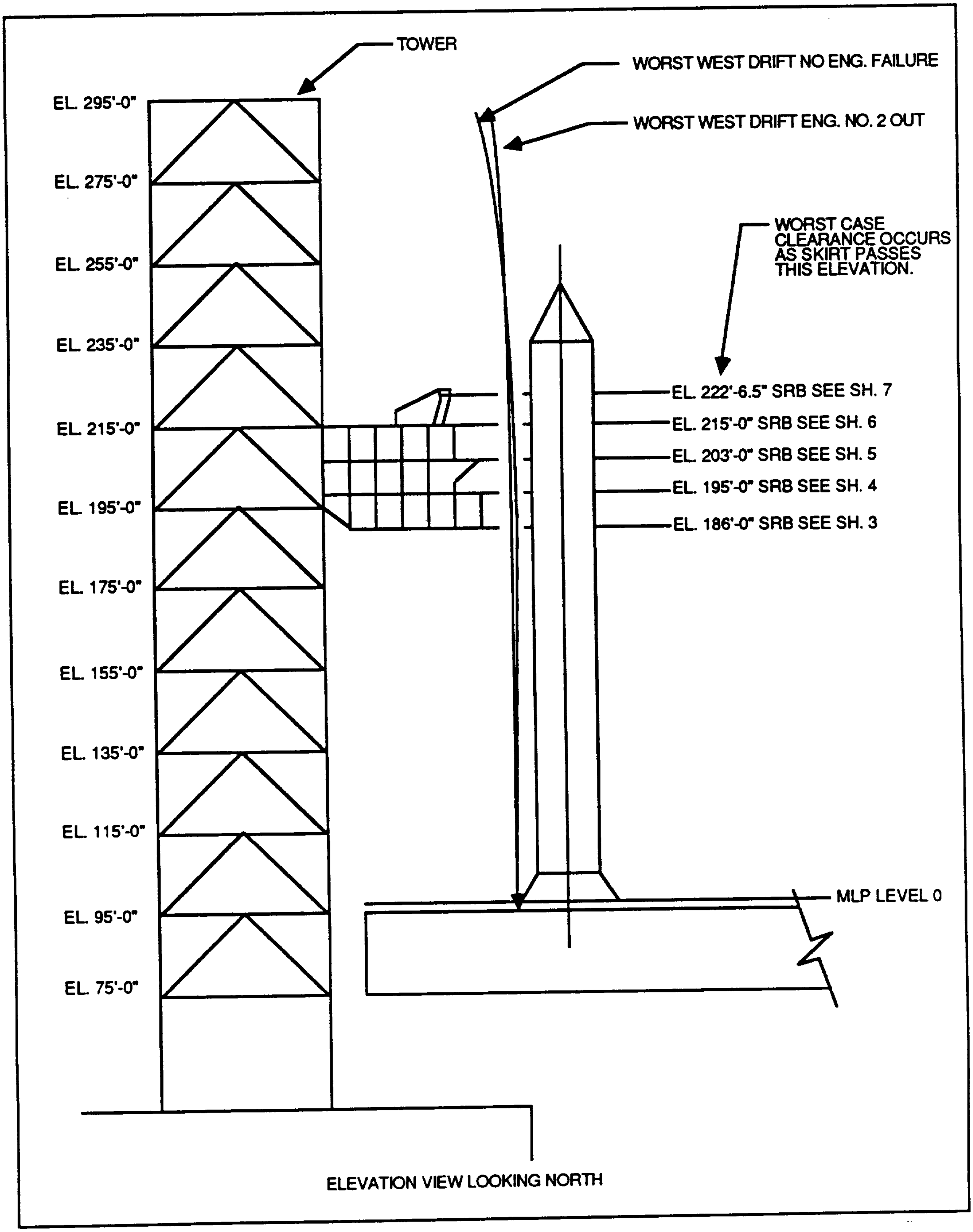


Figure 3.4.3.5-1. SRB To ET Vent Arm Clearances.

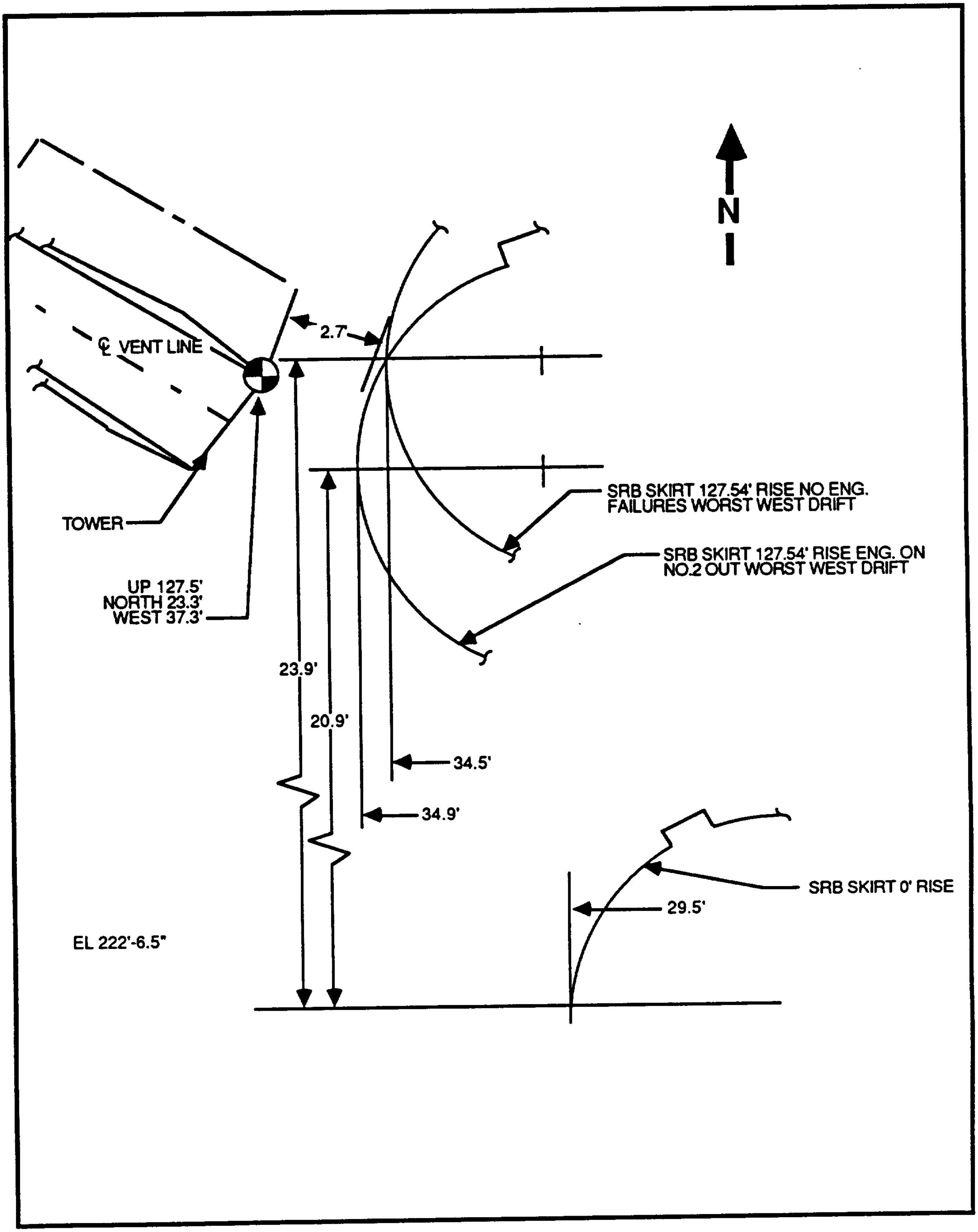
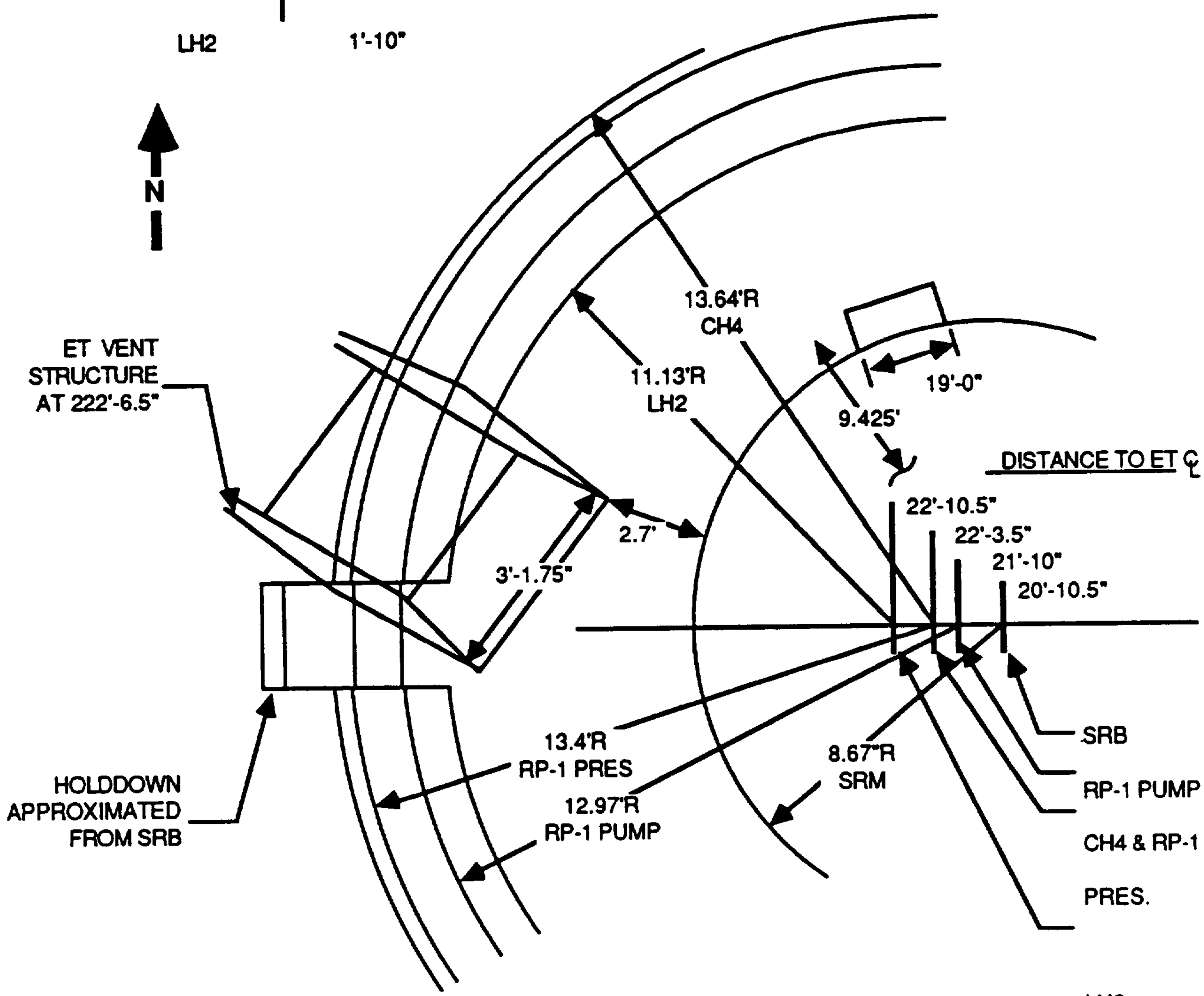


Figure 3.4.3.5-2. SRB Skirt To ET Vent Arm Clearances.

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3.4.5 11/11 2:30p

LRB	INTERFERENCE
RP-1 PUMP	2'-9"
RP-1 PRES	3'-7"
CH4	3'-10"
LH2	1'-10"



USING WORST WEST DRIFT FOR SRB (ENG. NO 2 OUT) 222'-6.5"

*MM RP-1 PUMP AND PRESS HAVE SIMILAR INTERFERENCES

Figure 3.4.3.5-3. ET-GH2 Vent-LRB (GDSS) Skirt To ET Vent Drift Study.

3.4.5 11/8 1:00p

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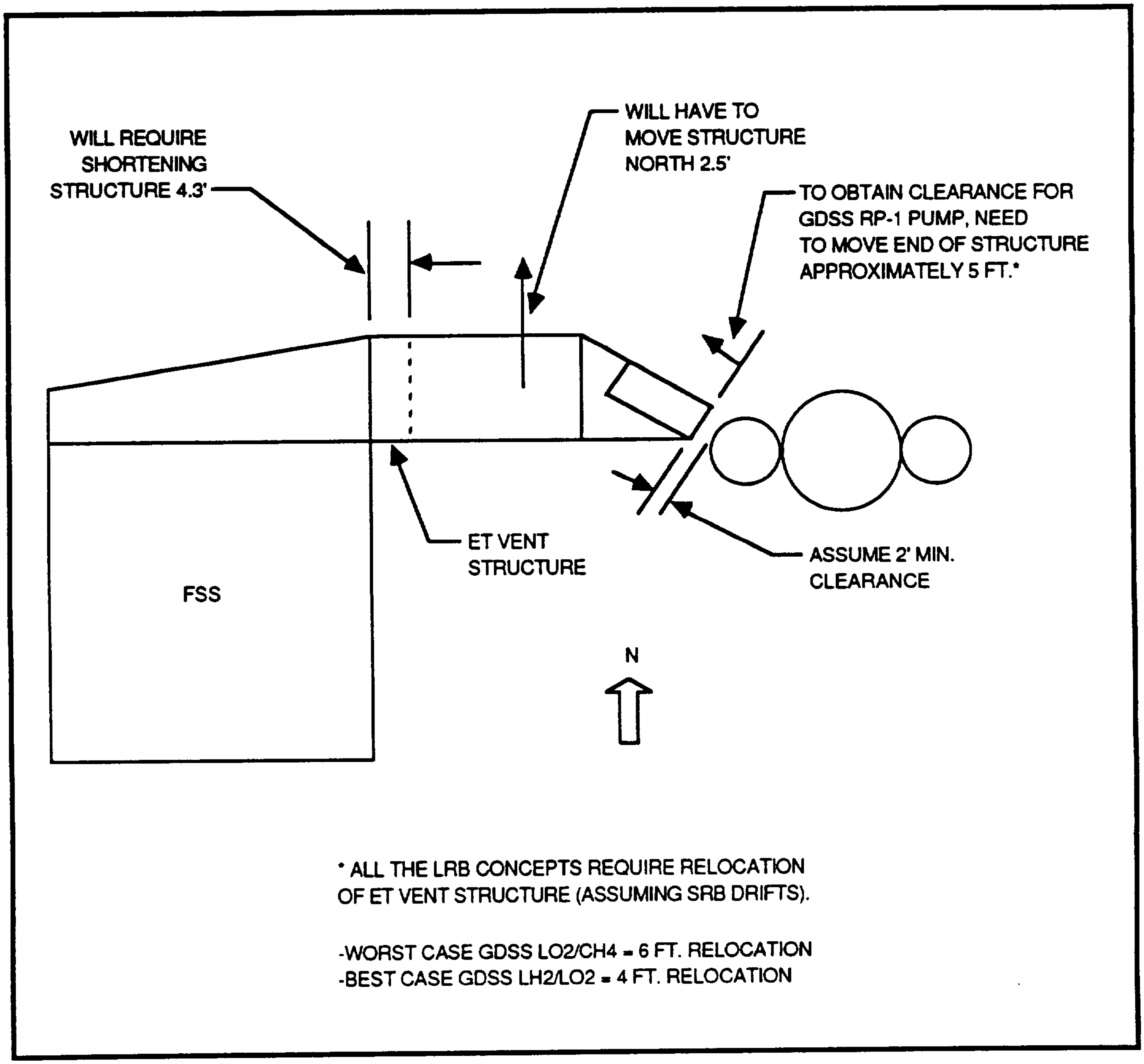


Figure 3.4.3.5-4. ET H2 Vent-ET Vent Structure Relocation For LRB Clearance.

retracted.) Furthermore, lengthening the vent line would aggravate the already marginal safety factor for the pyro-bolt, which holds the umbilical to the vehicle. Maintaining the pyro-bolt load within acceptable limits could prove very difficult and could lead to revision of the basic operating principles of the umbilical.

In summary, if relocating the ET vent structure is necessary, an extensive design and modification effort would be required, along with LETF requalification testing.

The second area of concern for the ET vent deals with clearance of the LRB during umbilical disconnect and retract. Figure 3.4.3.5-5 shows a plan view of the vehicle and umbilical at the start of a secondary disconnect. Figures 3.4.3.5-6 and 3.4.3.5-7 show the worst case clearance as the umbilical swings past the SRB. Figure 3.4.3.5-8 lists the resulting clearance (or interference) after substituting the larger LRB diameters. As shown, only the GDSS RP-1 pump-fed has any clearance remaining. Assuming a clearance of 12 inches is desired for all cases, some modification would have to be made to the umbilical.

Figure 3.4.3.5-9 presents a concept which could alleviate this problem. The concept involves using a cam arrangement on the vent line pivot, which would swing the umbilical around the LRB during retract. This concept could conceivably be implemented without major modifications to the system. However, some LETF testing would be required.

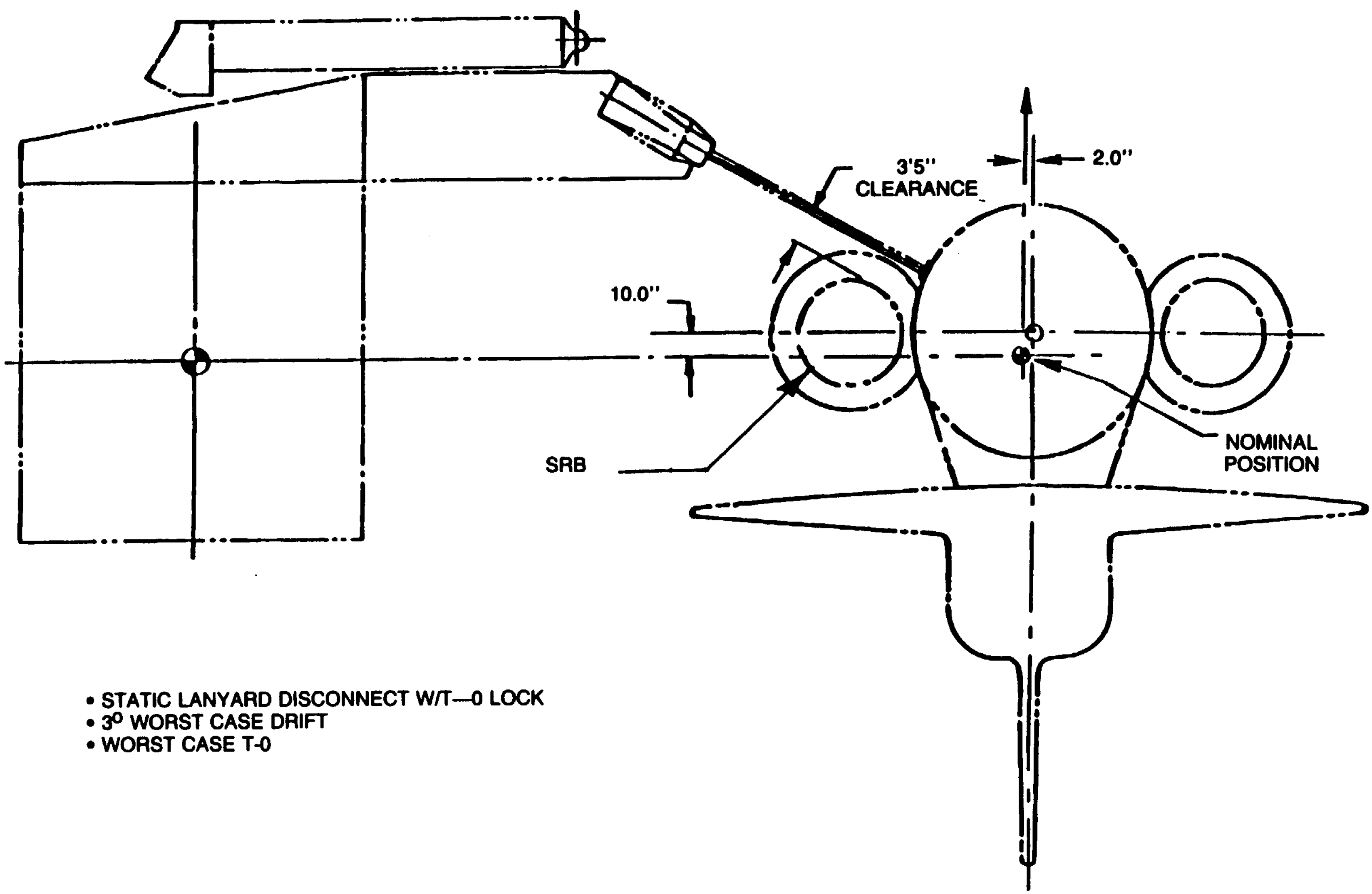
3.4.3.6 <u>Conclusions and Recommendations</u>

The major impacts to existing umbilicals and swing arms for the six LRB concepts under consideration (based on the assumptions of this study) are as follows:

<u>GOX Vent</u> - Due to their length, the employment of the GDSS RP-1 and LH2 LRBs would require extensive modifications to this umbilical.

<u>ET H2 Vent</u> - All six LRB concepts would require extensive modification to this umbilical to provide adequate vehicle drift clearance. Additionally, all the LRBs would necessitate umbilical changes to ensure clearance during disconnect and retract.

TIME: T + 0.67 SEC

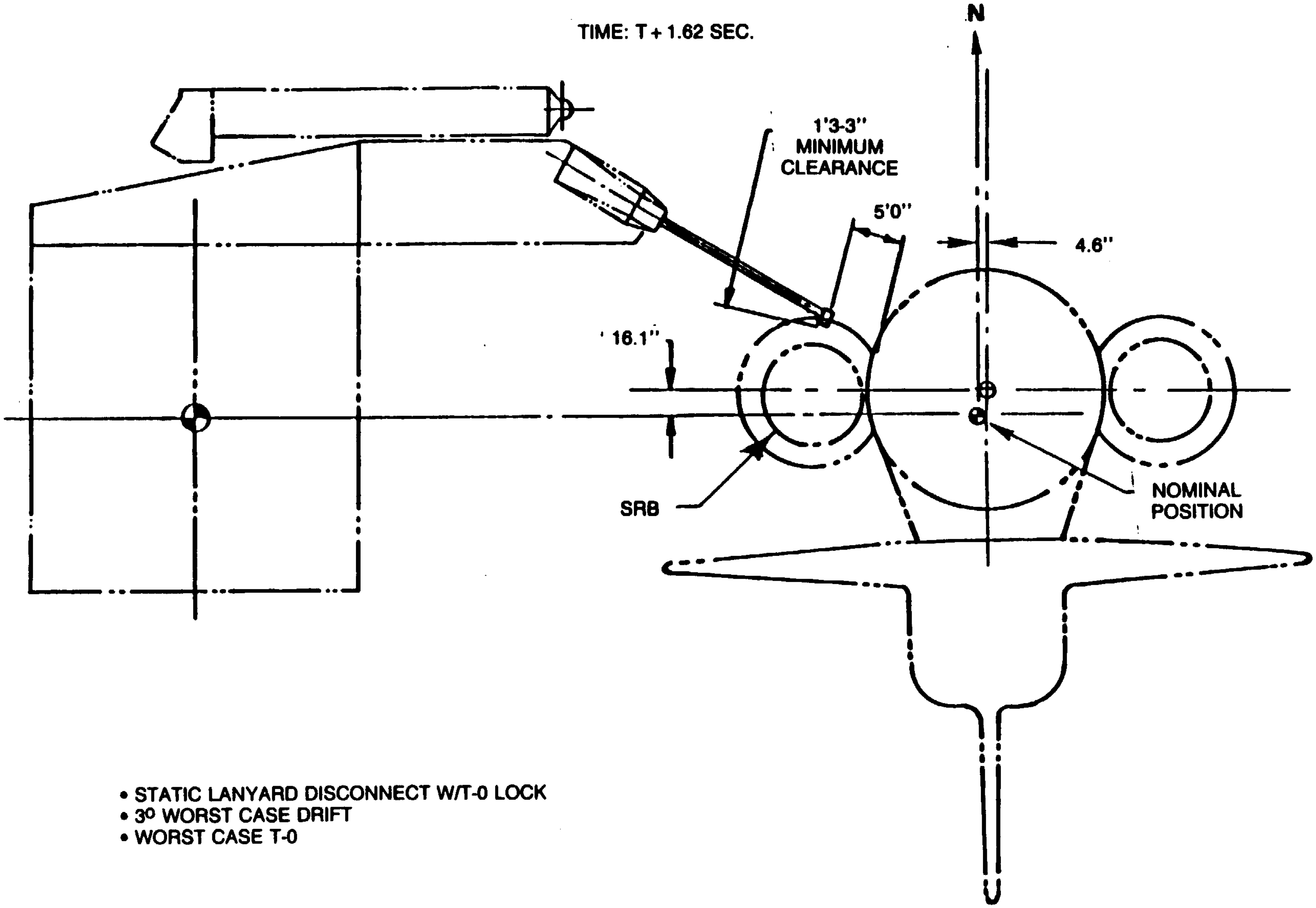


• STATIC LANYARD DISCONNECT W/T—0 LOCK
• 3° WORST CASE DRIFT
• WORST CASE T-0

Figure 3.4.3.5-5. ET Hydrogen Vent Umbilical Disconnect and Retract Clearance, Plan T + 0.67 sec.

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• STATIC LANYARD DISCONNECT W/T-0 LOCK
• 3° WORST CASE DRIFT
• WORST CASE T-0

Figure 3.4.3.5-6. ET Hydrogen Vent Umbilical Disconnect and Retract Clearance, Plan T + 1.62 sec.

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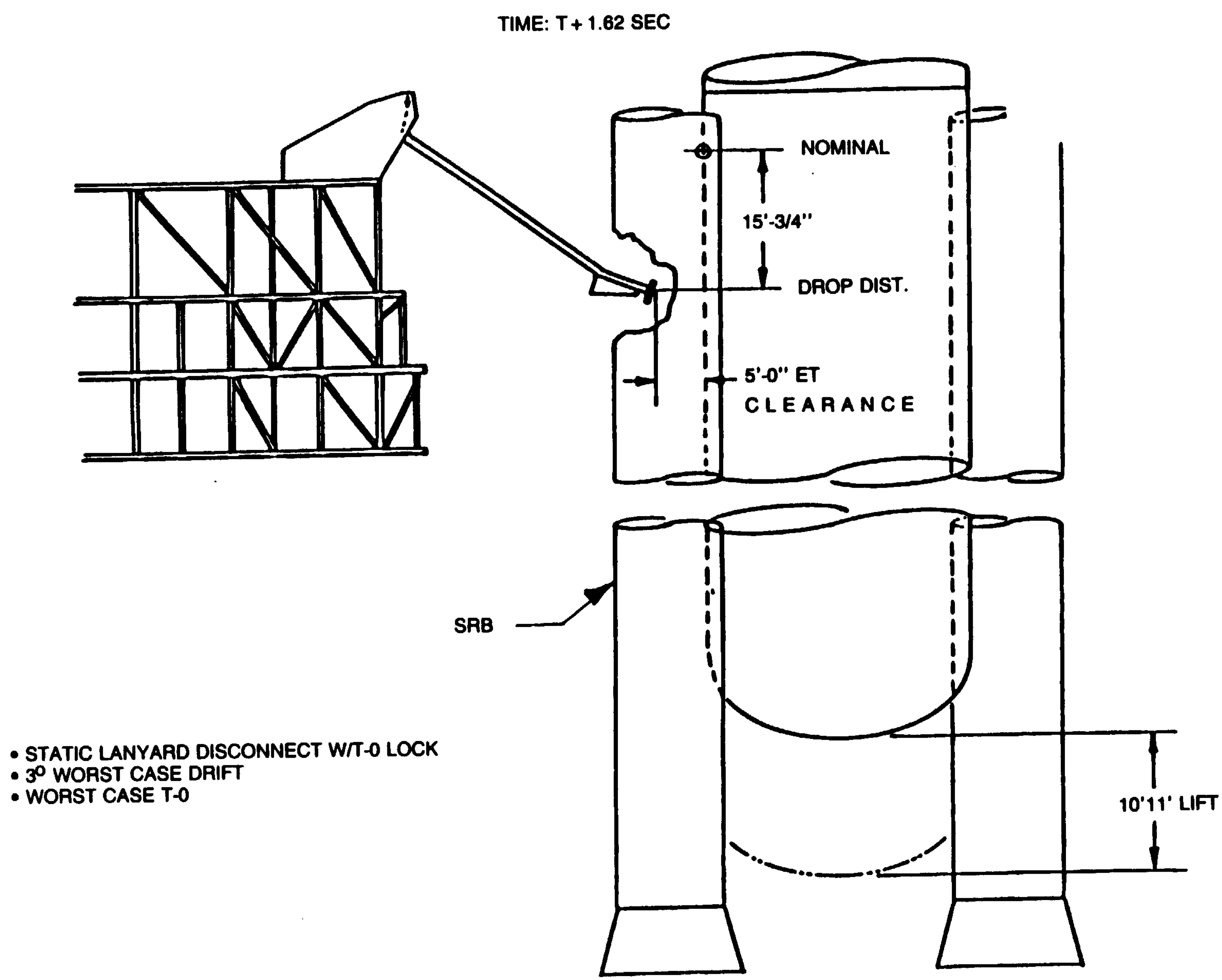


Figure 3.4.3.5-7. ET Hydrogen Vent Umbilical Disconnect and Retract Clearance, Elevation T + 1.62 sec.

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BOOSTER		DIAMETER	Δ RADIUS	WORST CASE CLEARANCE
GDSS	SRB RP-1 PUMP CH4 PUMP RP-1 PRESS LH2	12'-2" 14'-1" 15'-0" 15'-0" 16'-2"	— 11.5" 1'-5" 1'-5" 2'-0"	1'-3" 3.5" 2" INTERFERENCE 2" INTERFERENCE 9" INTERFERENCE
MM	RP-1 PUMP RP-1 PRESS	15'-4" 16'-2"	1'-7" 2"-0"	4" INTERFERENCE 9" INTERFERENCE

*WILL APPROXIMATE FROM SRB CLEARANCE STUDY KSCL-1792B-0101

*A MINIMUM CLEARANCE OF 1'-3" BETWEEN THE SRB ANB VENTLINE WAS PREDICTED FOR A WORST CASE DRIFT WITH A SECONDARY UMBILICAL RELEASE.

*TO APPROXIMATE CLEARANCE FOR LRB'S WILL ONLY CONSIDER CHANGE IN BOOSTER DIAMETER.

Figure 3.4.3.5-8. ET Ventline To LRB Clearance During Ventline Drop.

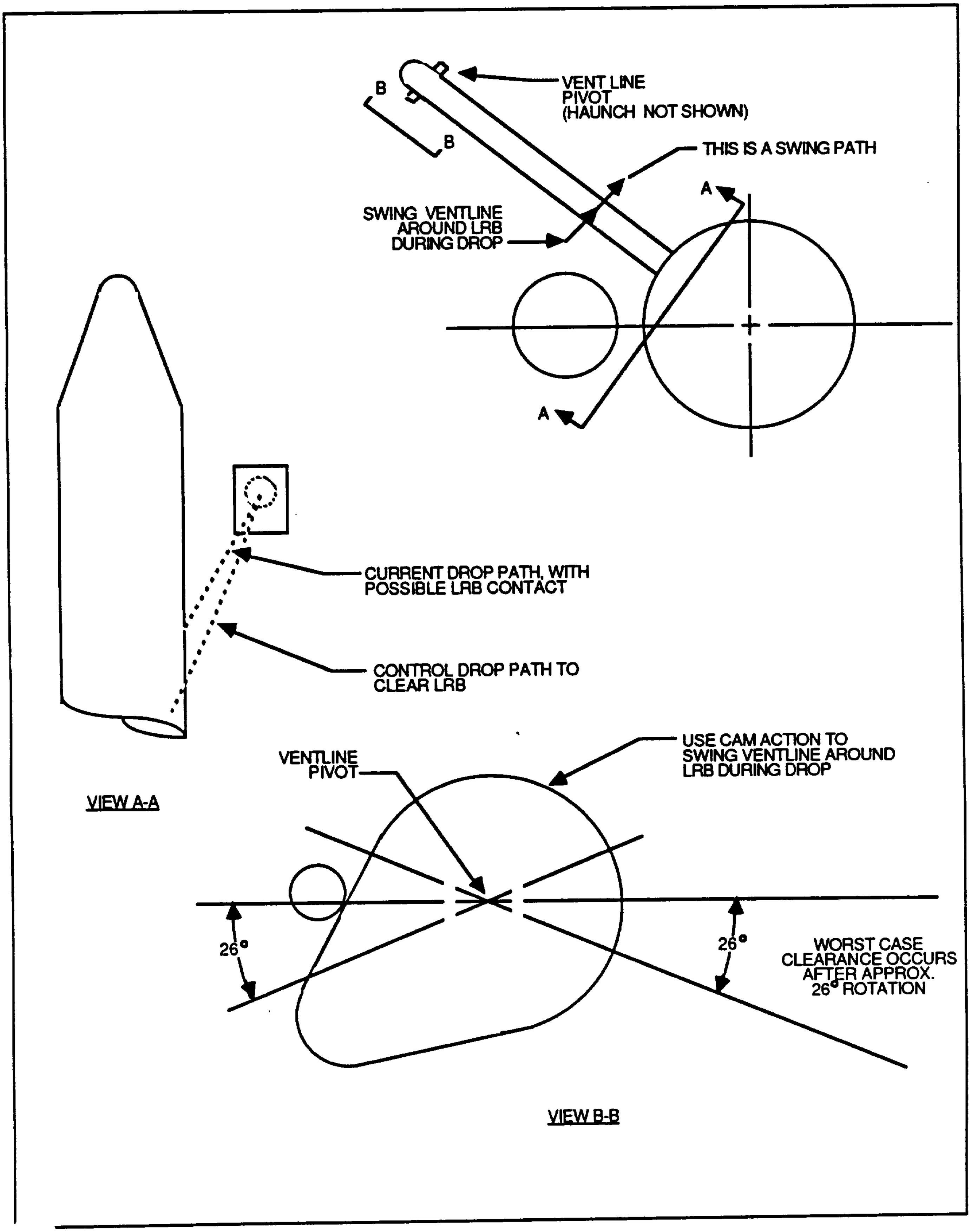


Figure 3.4.3.5-9 ET Hydrogen Vent Umbilical and Retract Clearance.

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3.4.4 Orbiter Weather Protection System

This section will identify the impacts to swing path of the -Y curtain wall by the LRB concepts.

3.4.4.1 Groundrules

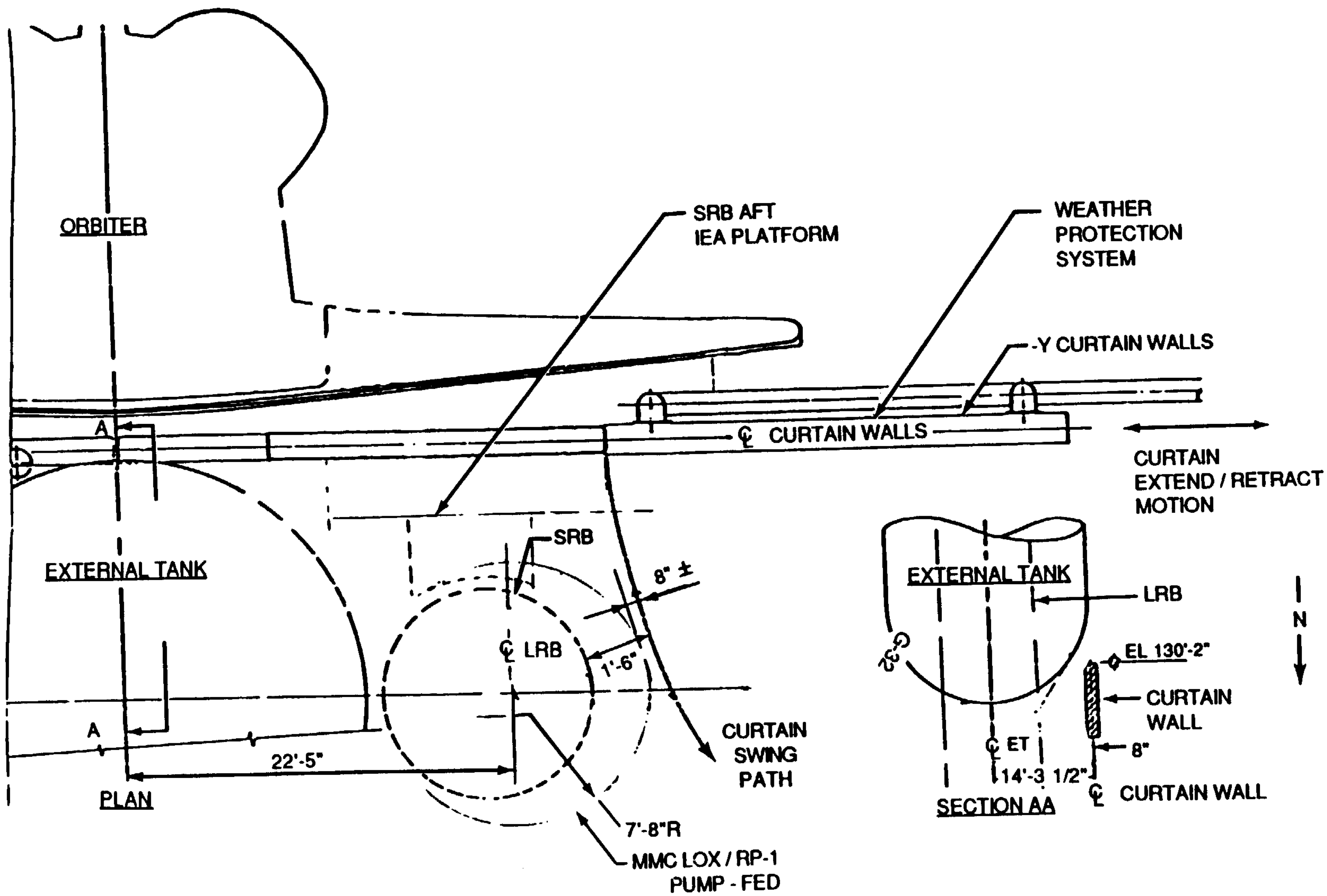
A dynamic clearance of 1 foot six inches must be maintained from flight hardware to hard steel.

3.4.4.2 Impacts

The MMC LOX/RP-1 pump-fed LRB concept in Figure 3.4.4.2 shows a clearance of 8 inches from the -Y curtain wall during the extend/retract operation. All other LRB concepts with larger diameters will have a greater impact.

3.4.4.3 Conclusions and Recommendations

The direct affects on the existing Orbiter weather protection system cannot be addressed thoroughly in this study. The modifications required would be determined by structural analysis and further design study upon completion of LRB down selection.



81005-01L

Figure 3.4.4.2. Launch Pad Weather Protection System.

3-3.4 11/11 2:30p

3.5 LAUNCH CONTROL CENTER (LCC)

This section of the study identifies impacts to the Launch Processing System (LPS) that would result from the introduction of LRBs at KSC. It defines requirements for LPS hardware; Checkout, Control and Monitor System (CCMS) software; and application software in the LCC Firing Rooms.

3.5.1 Firing Room LPS Requirement for LRB

This paragraph identifies the impacts to the LPS hardware and CCMS system software resulting from LRB processing in the Firing Rooms. Software estimates in lines of code are provided to quantify the results in existing LPS hardware equivalents.

3.5.1.1 Impacts

The LPS hardware impacts the result of the additional software and operational requirements that the LRB will have upon the users of the CCMS and the Record and Playback System (RPS). The introduction of LRB requirements will entail the need for additional consoles in the Firing Rooms and changes to the CCMS system software.

Console Assignments: LRB operations in the Firing Room will require additional personnel to monitor the LRBs during propellant loading and terminal count. As a result, each of the four operational Firing Rooms will require three additional consoles in addition to a reassignment of existing systems to consoles.

Additional LPS Equipment: Two new Pulse Code Modulator (PCM) type Front End Processors (FEPs) will be required to support LRB data. Two additional PCM type FEPs may be required if the LRB PCM data comes down independent from the Orbiter 128 KB PCM.

LPS System Software: The System Software assessments are based on expected impacts for new command capabilities, new data types, and new PCM data streams, and does not include the necessary changes to support more than 15 consoles in the Firing Room.

3.5.1.2 Requirements

The quantity of application software as well as the need for operator positions during Firing Room operations necessitates the addition of new consoles.

The new consoles will be assigned in following manner:

1. LO2 and LRB MPS
2. RP-1 and LRB Engines
3. HAZGAS (will have to move out of C9 to make room for LRB INST)

Personnel and software for the GNC, DPS, COMM, EPDC, INST, umbilicals, and the RSS will remain with their consoles and be integrated into the existing software design architecture.

Due to the expected need for new command, the capabilities, new data types, new PCM data streams, and existing CCMS system software will require modifications.

The Figure 3.5.1.3 shows breakdown of the anticipated system software impacts by functional area.

3.5.1.3 Conclusions and Recommendations

To accommodate LRBs during launch countdown and the additional quantity of application software required for the operational conditions of LRBs during this period, each of the Firing Rooms will require additional LPS hardware. Each of the four Firing Rooms will need: three new LPS type-1 consoles, and either two or four new PCM-type FEPs, depending on whether the LRB PCM data comes independent from the Orbiter 128 KB PCM. Reallocation of the existing personnel and software will also be necessary.

To accommodate new command types, data streams, and data types posed by LRB systems, approximately 900,000 lines of CCMS system software will be required. Further study will be required to determine the impact of exceeding the current limitation of fifteen consoles in a Firing Room.

The CCMS equipment in the Firing Rooms will not support the expansion foreseen to support LRBs. Because no equipment of this type is available, LPS 2 will be necessary for the upgrade of

SYSTEM	LINES AFFECTED
SYSTEM BUILD	250,000
EXECUTORS	100,000
OPERATING SYSTEM	100,000
FEP	150,000
RETRIEVAL	200,000
CONSOLE	50,000
SGOS	100,000
RPS	100,000
TOTAL	950,000

Figure 3.5.1.3. Anticipated System Software Impacts by Area.

the Firing Room CCMS equipment. This proposed use of LPS 2 equipment should be feasible because the timelines for LPS 2 development very closely match those projected for the LRB. The needed equipment has been projected in existing CCMS types.

3.5.2 LPS Application Software Requirements for LRB

This paragraph identifies impacts to LPS application software and other software in the development process. To quantify the existing contents and provide an estimate of the resulting changes in the form of lines of code and percentage.

3.5.2.1 Impacts

The LPS applications software assessment was based on a percentage of existing software expected to change or be added as a result of switching to a Liquid Rocket Booster. The existing Firing Room application software was reviewed by using equivalent Shuttle systems to represent the LRB onboard systems, as well as knowledge of existing GSE, procedures, and operating methods; i.e. the RP-1 estimate was derived by using the LH2 system. SGOS models used to perform software verification and validation were estimated in the same manner. The expected configurations of the various systems and subsystems were estimated by comparative analyses to similar systems aboard the Orbiter. Relative numbers of console displays used during the different tests performed on the Shuttle during both processing and launch countdown were assessed.

The operational philosophy and current assignments of system responsibilities within the Firing Room make it feasible for all systems to be operated and monitored by personnel currently performing these tasks on the Orbiter, ET, and SRBs, with the exception of LRB engines and propellant systems.

The Ground Launch Sequencer (GLS) is an exceptionally time critical set of application software. The effects of adding eight new engines and their impacts on the terminal countdown, abort, and safing procedures will necessitate the rewrite of the entire GLS to include LRBs.

3.5.2.2 Requirements

The Figure 3.5.2.2 shows a breakdown of the expected system that will change, the approximate lines of code (existing), the percentage used to determine the amount of code to be added or changed (% delta), and the number of lines expected to be changed or added (lines delta).

3.5.2.3 Conclusions and Recommendations

Approximately 900,000 lines of code will have to be written or modified to incorporate LRBs into Firing Room application software. In addition there will be approximately 1,000 new or modified display skeletons that will be required.

SYSTEM	EXISTING	% DELTA	LINES DELTA
EPDC	52,599	95%	49,969
TAVC	40,540	95%	38,523
INST	8,286	95%	7,862
RSS	16,298	95%	15,483
RP-1	35,076	95%	33,322
LO2	36,448	95%	34,625
ETCO	15,202	95%	14,442
ENGINES	121,004	95%	114,954
UMBILICALS	10,094	25%	2,523
GNC	275,084	35%	131,280
DPS	21,868	40%	8,750
INTG	4,638	95%	4,406
COMM	21,320	25%	5,330
HAZGAS	16,800	30%	5,040
FSW	20,117	20%	4,024
GLS	100,000	100%	100,000
CCS	1,500,000	10%	150,000
ESA	160,000	50%	80,000
MODELS	200,000	50%	100,000
TOTAL	2,655,374	34%	900,533

Figure 3.5.2.2. Lines of Code Change by System.

3.6 MLP PARKSITE # 2 REACTIVATION

This section will define the requirements necessary to reactivate the MLP parksite #2 to support construction or modification of MLPs. Figure 3.6 shows the general arrangement of the parksite.

3.6.1 Description

For reactivation, the MLP parksite #2 will be upgraded to provide the same services as the other parksites.

Electrical Requirements Specific power requirements are provided in section 3.8.

Fire Control A firex pump unit and supply is required to supply the MLP firex system.

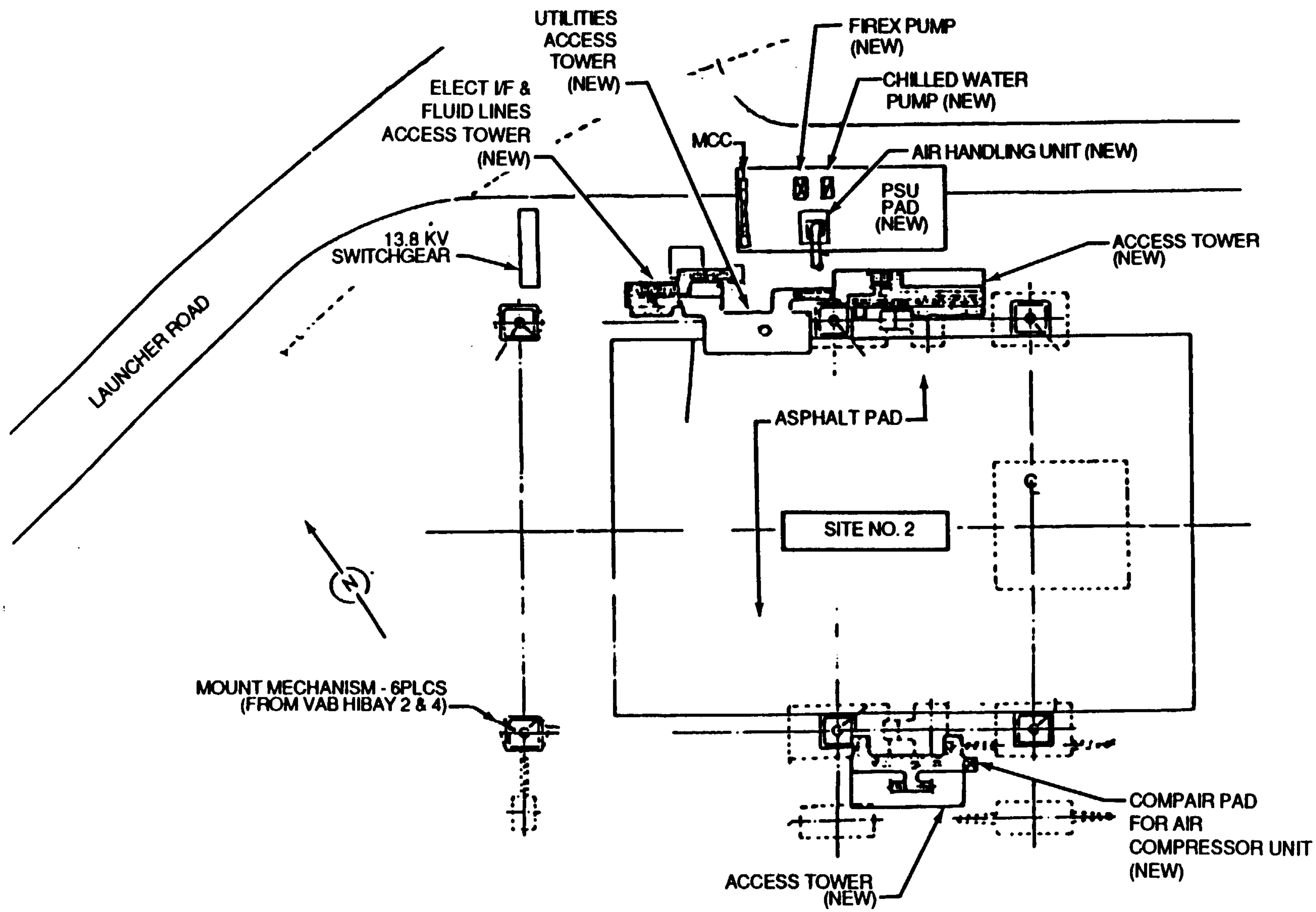
Potable Water Potable water is required to supply the Heating, Ventilating, and Air Conditioning (HVAC) chilled water unit for conditioned purge air.

HVAC An air handling unit is required for a conditioned air supply for purging the interior locations of the MLP.

Pneumatics A compressed air unit is located at this site to supply shop air to MLP for tools, equipment, and HVAC controls.

Structural Concrete pads and access towers are required for electrical, fluid, and utility services to allow a tie-in to the MLP. Access towers are also required for personnel access to the MLP.

Existing mount mechanism locations require preparation by removal of concrete caps and sand covering these pads, which were installed during deactivation. Six mount mechanisms are required to support the MLP. These are available from Highs Bay 2 and 4.



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Figure 3.6. MLP Parksite # 2 - General Arrangement.

3-3.6 10/28 8:00a

3.7 LAUNCH EQUIPMENT TEST FACILITY (LETF)

This section defines the capabilities and access impacts of the LETF to support LRB LSE test and qualification.

3.7.1 LETF Capability

The LETF provides the capability at KSC to qualify and certify operationally, the functionability, reliability, and maintainability of critical launch support equipment. This certification is performed prior to installation of the equipment at the launch pad or on the MLP.

The LETF has the capability to simulate SSV motions and excursions before launch and at lift-off. The simulations tested include fueling, purging, environmental conditions (wind), system power-up and power-downs, emergencies, and holds. The emergencies and holds include main engine shutdown. Simulations for flight readiness firing (FRF) and other lift-off motions are also performed. See Figure 3.7.1 for general arrangement of the LETF.

3.7.2 LRB LSE Test Requirements

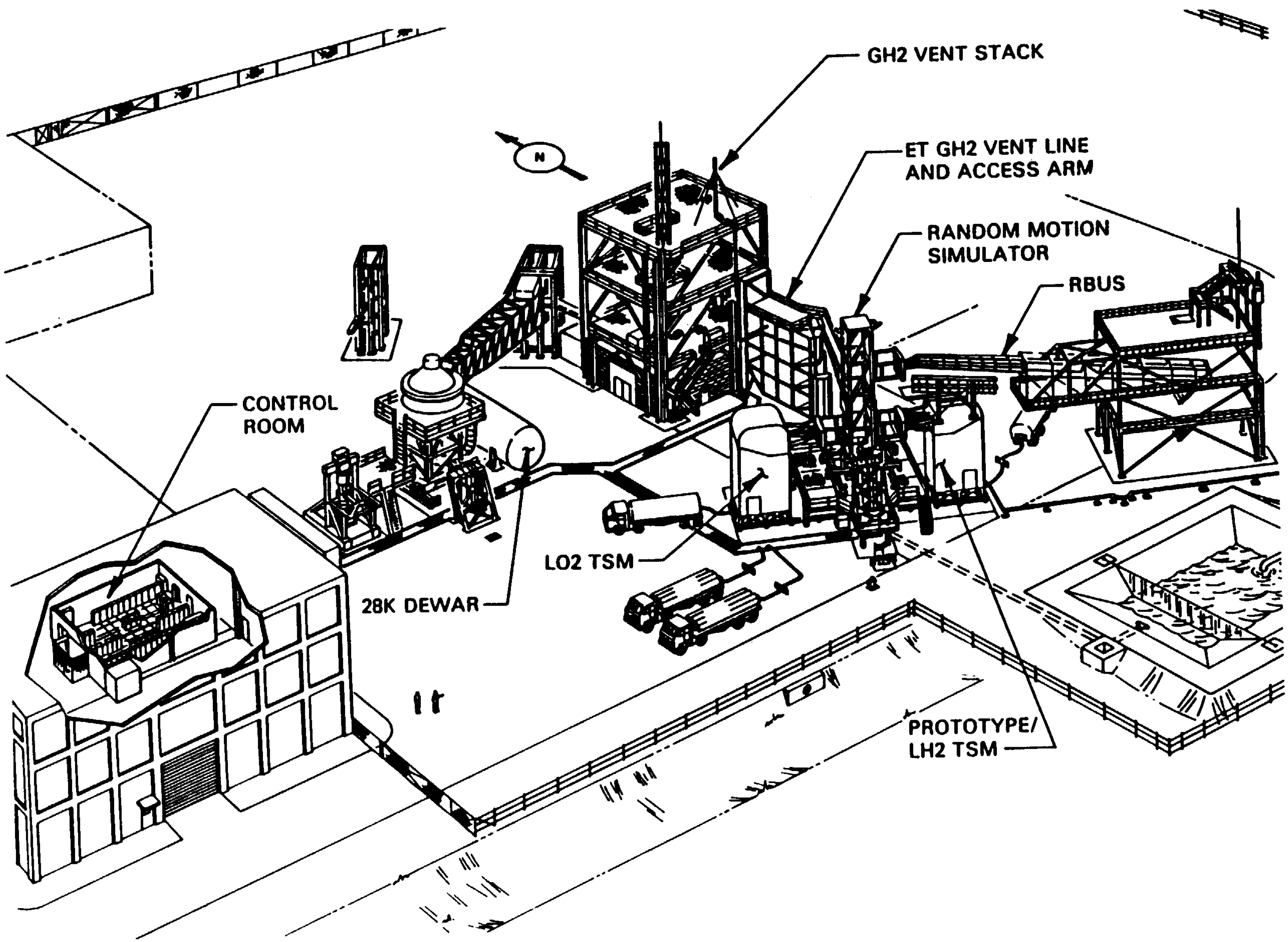
All LSE currently indentified for LRB must be tested at the LETF. Figure 3.7.2 lists the candidate LRB LSEs which require qualification. Section 4 provides descriptions and definitions of this equipment. Each item will be required to qualify prior to installation on the Pads or MLPs.

3.7.3 Orbiter/ET LSE Test Requirements

Any LSE (ET H2 vent, GOX vent, TSM) that requires modification or redesign for integration of LRBs must be retested and qualified. Figure 3.7.3 lists candidate LSEs. Section 3 (Paragraph 3.3.4 and 3.4.5) describes the expected impact and conceptual redesign of the candidate LSE that would require testing.

3.7.4 Site Impact

For new umbilical and mechanisms testing, fabrication and installation of simulators will be required. The simulators will be required to adapt to the existing random motion and lift-off simulators.



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Figure 3.7.1. LETF General Layout.

3-3 11/11 2:30p

CANDIDATE LSE \ LRB OPTION	MM LO2 / RP-1 PUMP	MM LO2 / RP-1 PRESSURE	GDSS LO2 / RP-1 PUMP	GDSS LO2 / RP-1 PRESSURE	GDSS LO2 / LH2	GDSS LO2 / CH4
NEW LO2 UMB FOR EACH LRB (2 EACH MLP)	X	X	X	X	X	X
NEW LH2 UMB FOR EACH LRB (2 EACH MLP)					X	
NEW CH4 UMB FOR EACH LRB (2 EACH MLP)						X
NEW GH2 VENT LINE & SWING ARM FOR EACH LRB (2 EACH PAD IF REQD)					X	
NEW CH4 VENT LINE & SWING ARM FOR EACH LRB (2 EACH PAD IF REQD)						X
NEW HOLDDOWN SYSTEM (8 EACH MLP)	X	X	X	X	X	X
NEW POWER / INST. FOR EACH LRB (2 EACH MLP)	X	X	X	X	X	X
NEW RP-1 UMB & SERVICE MAST FOR EACH LRB (2 EACH PAD)	X	X	X	X		

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Figure 3.7.2. LRB LSE LETF Test Requirements.

3-3.7 11/11 2:30p

CANDIDATE LSE	MOD RETEST
ORBITER ACCESS ARM (1EACH PAD)	MOD/RETEST DEPENDENT ON EXCURSIONS OF LRB/SSV.
ET INTERTANK ACCESS ARM (1 EACH PAD)	MOD/RETEST DEPENDENT ON EXCURSIONS OF LRB/SSV.
MOD OF ET GH2 VENT LINE / ARM SYS (1 EACH PAD)	MOD / RETEST DUE TO DIAMETER
MOD OF ET GOX VENT ARM AND SYS (1 EACH PAD)	MOD / RETEST DUE TO LENGTH
MOD OF LOX/LH2 TSM (2 EACH MLP)	MOD/RETEST DEPENDENT ON EXCURSIONS OF LRB/SSV.

Figure 3.7.3. Orbiter/ET LSE LETF Test Requirements.

Holddown post or mechanisms and the blast shield will require fabrication of a test fixture to simulate static, FRF, and lift-off loads. Any modifications to existing Orbiter/ET LSE or the existing test stands and fixture would be tested. The existing facility control room and facility equipment can be modified to accommodate the testing of LRB LSE.

Site modification requirements will include fabrication and installation of a test simulator for each umbilical and installation of electrical cabling, instrumentation, and fluid lines. It is assumed that the present hardware interface module (HIM), power distributor system, and fluid system, although requiring modification, are adequate to support the test requirements. A new LRB holddown system test fixture would be required.

It is assumed that the LRB skin panel (flight umbilical), ground carrier plates, and flight ground disconnects will be provided by the LRB contractor.

3.7.5 Test Requirement Flow

It is estimated that after facility design it will take 8 months to have the LETF ready to support an LRB LSE test program. The length of time for testing is dependent on the number of umbilical/mechanisms that require testing. Six months of testing for each LRB umbilical or modified Orbiter/ET umbilical will be required.

Assuming only two lift-off umbilicals per booster (two fuel, two LOX) and redesign of the Pad ET H2 vent, the testing would take 30 months (6 months each). The holddown system and blast shield will require 1 month of testing each. This adds up to 8 months of holddown system testing. This example results in a 38 month test program. Any additional LRB umbilical or Orbiter/ET tests would add six months for each item to the test program.

A TSM requalification program would take approximately three months (1-1/2 months each).

3.8 LC-39 FACILITY REQUIREMENTS

3.8.1 Power Requirements

This section defines the electrical power impacts to the KSC facilities and distribution systems, provides reviews of all KSC station sets affected by the processing of LRBs, determines the power requirements, and identifies the impacts to the C-5 substation.

3.8.1.1 ET/LRB Horizontal Processing Facility (HPF)

Facility Requirements

The proposed HPF will have five different areas that will have unique power requirements with respect to each other that would result from the types of work performed in those areas. These requirements are not, however, unique to other areas and facilities at KSC.

Two areas encompass the vehicle element processing bays. Both the LRB and the ET processing bay concepts include at least one overhead crane in each bay. Lighting throughout the area and supplies to access platforms will be required. The general work areas, including the platforms, would be provided with 120 V ac, 208 V ac, 480 V ac at 60 Hz, and 60-Hz emergency power. The emergency power would be supplied, as with other KSC facilities, by the C-5 emergency generators. This emergency system would provide power for lighting, exit lights, and the fire alarm system.

The next two areas involve the vehicle element storage and surge areas. The HPF concept includes storage and surge areas for both the ETs and the LRBs. These two hangar-type areas would require lighting, 120 V ac, 208 V ac, 480 V ac at 60 Hz, as well as 60-Hz emergency power.

The fifth area basically consists of shops and offices. These areas consist of two floors located between the LRB and ET processing areas. The first floor would house the various shops for batteries, engines, etc.; a logistics storage area, and the power and electrical equipment room. The second floor would house an office for administrative personnel and the computer control room for testing of the vehicle elements.

The power requirements for the various shops and the logistics area would be similar to those of the processing areas. Various voltages and emergency power would be supplied, including power

required for hoists (120 V ac) and emergency power. The second floor power requirements would be limited to 120 V ac in the office/administrative area and emergency power provided. The computer control room, because of the nature of the computers, would have an uninterruptible power supply (UPS).

<u>AC Power Supply Requirements</u>

The ac power supply for the HPF will require two double-ended 2,000-amp substations for 60-Hz power. One side of the substation would have a primary input switch fed from a 13-kV feeder from the C-5 station. The primary switch would feed the primary side of a dry-type transformer, which would step down the 13.8 kV to 480 V, while at the same time increasing the output current with a transformer output feeding the main circuit breaker. Contained in the same rack with the main circuit breaker would be an instrument panel that monitors the 3-phased voltage output and the load current of each phase. The instrument panel output signal would be required to be monitored at a console in the second floor control room. The main circuit breaker would be capable of feeding up to 12 secondary circuit breakers. All breakers would be required to be monitored and controlled from the control room console. The secondary breakers would feed all the branch circuits throughout the facility. Distribution panels with up to 42 circuits, transformers to step down 480 V to 220 V or 120 V, and safety switches for heaters and pumps would be supplied power from the secondaray breakers.

The other side of the double-ended substation will have the same configuration. Both ends of the substation would be tied together with a tie-breaker, which would carry the load from one end to the other in the event that one side fails. The total load current for both ends cannot exceed the capacity of the dry-type transformer. This would make the substation a redundant system. See Figure 3.8.1.1-1.

<u>60-Hz Emergency Power Supply Requirements</u>

The 60-Hz emergency power system is required to remain operational in the event that the primary source of 60 Hz power, supplied by a double-ended substation, fails. Critical circuits, such as emergency exit lights and fire alarms, are fed through automatic transfer switches, which seek a power source, and which are in turn fed by an emergency substation. All emergency substations in the LC-39 area are fed through the 518 Feeder from the C-5 substation. Emergency 60-Hz power is supplied to the entire LC-39 area, which automatically start upon a loss of commercial power, from the C-5 emergency generators.

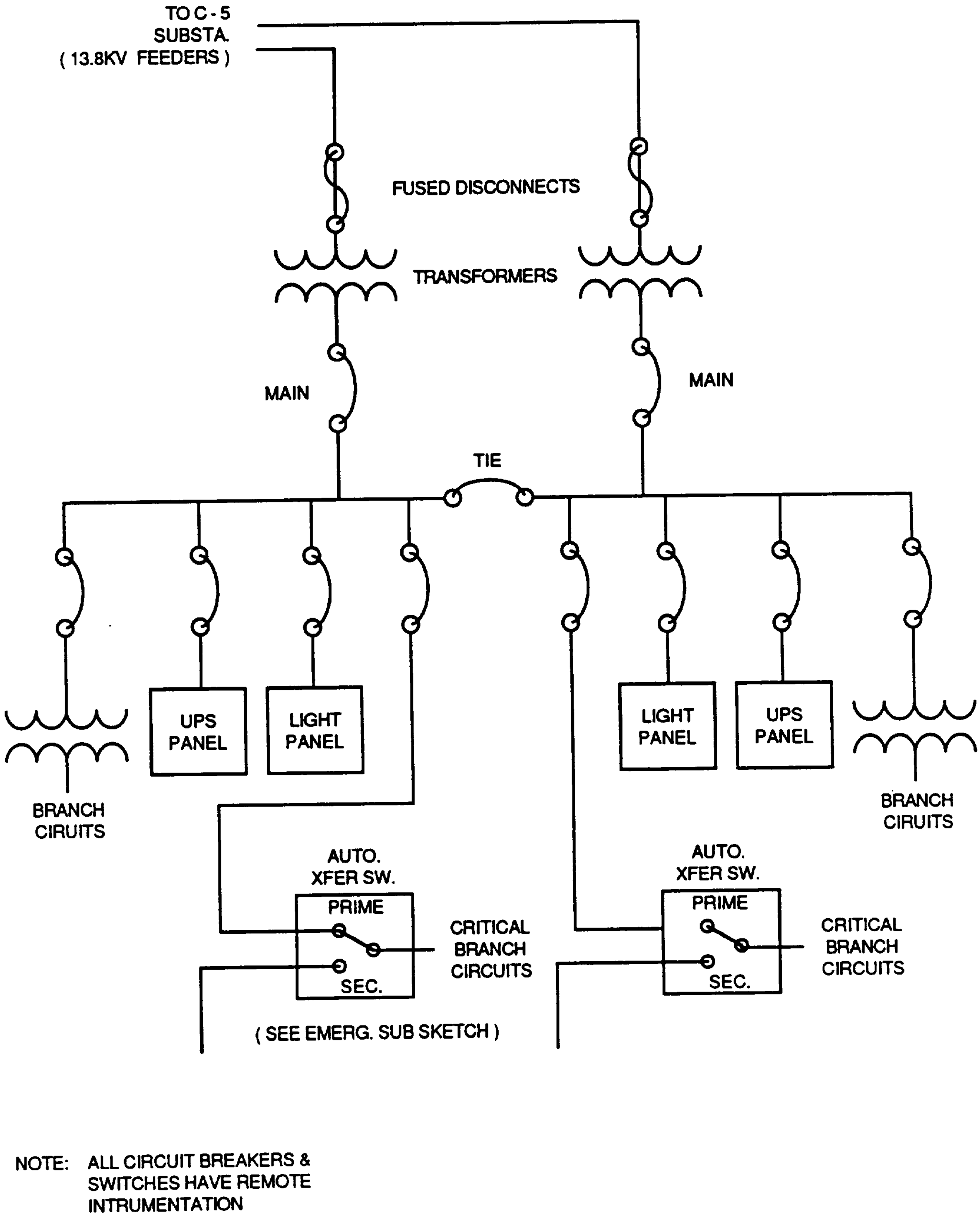


Figure 3.8.1.1-1. Typical Double-Ended Substation.

An emergency substation at the HPF connected to the emergency power system will satisfy all emergency power requirements for lighting used for evacuation, exit lights at all doors, and other critical circuits that must remain on during an emergency. See figure 3.8.1.1-2.

UPS Requirements

The 60-Hz power supplied to some facilities, services, and equipment is critical and therefore requires a UPS to maintain power. UPS is required for the cranes, for power lifts where personnel can be injured, fire alarm systems, sensing systems for safety of personnel, and computer systems. The UPS would be connected to the power line between the ac input supply and the critical load item.

Irregular ac power would enter the UPS and be converted to dc, which is reshipped by an inverter into precise, controlled, noise-free ac power for the critical load requirement. In the event of input line failure or ac line droop, the UPS battery bank would be required to continue the supply of clean and uninterrupted power. Figure 3.8.1.1-3 provides a schematic of the UPS.

Power Building

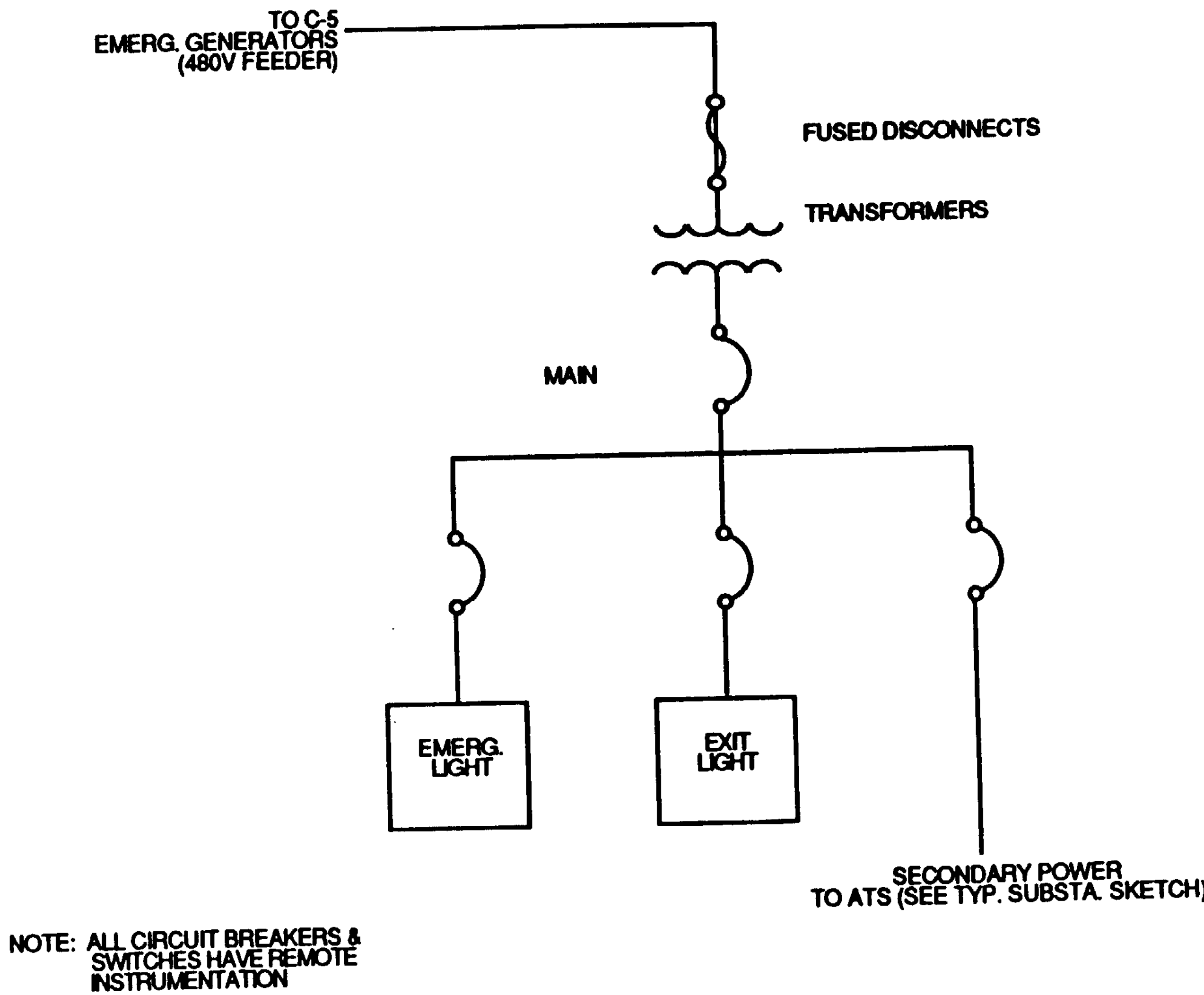
A detached building to house all power systems equipment including substation racks, panels, and transformers, will be constructed at the rear of the HPF. This building would require ventilation, a large door, and no windows. Figure 3.8.1.1-4 presents a layout of the power building.

3.8.1.2 VAB Integration Facility

High Bay 4 Requirements

At the present time High Bay 4 is used to process and store ETs vertically. Modifications to the High Bay would include restoring the 60 Hz power systems and providing two 13.8 KV feeders from C-5 substation. The feeders would terminate in power distribution racks and supply a double ended substation. Remote instrumentation and controls would be provided, as necessary, to support monitoring at the LCC. Power distribution would also provide power to the MLP through portable cables for connection.

High Bay 4 would require one feeder to supply emergency power from the C-5 emergency generators. The emergency feeder would terminate in a power distribution rack and supply a single ended substation which would also be monitored at the LCC. Power distribution using portable cables to connect to the MLP would provide an emergency power source.



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Figure 3.8.1.1-2. Typical Emergency Distribution System.

3-3.8 11/8 1:00p

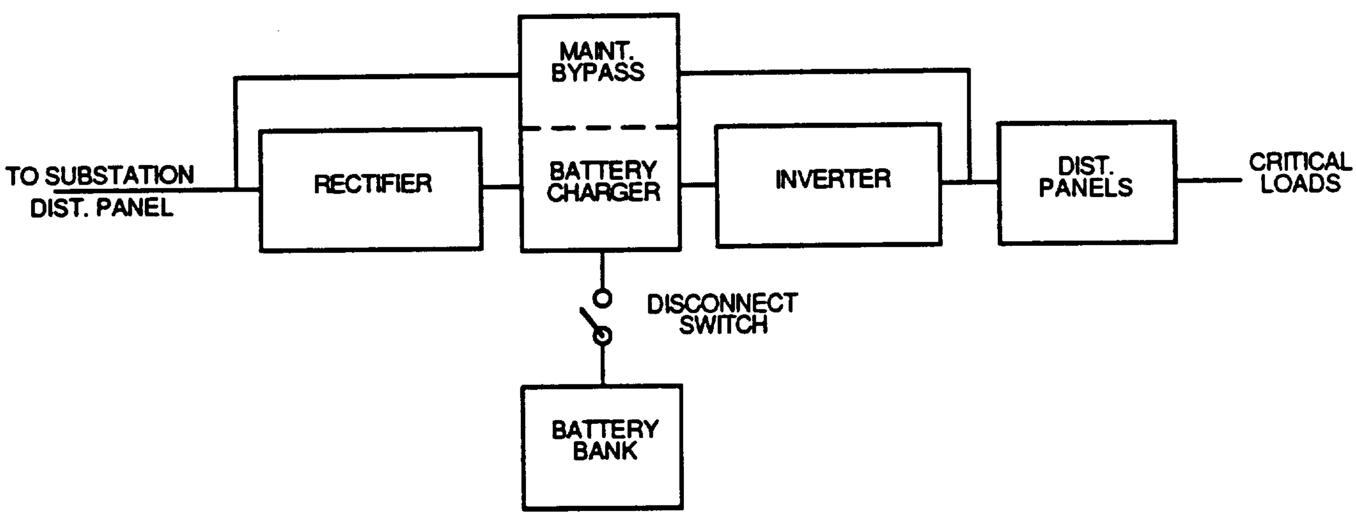


Figure 3.8.1.1-3. Typical Uninterruptable Power Supply.

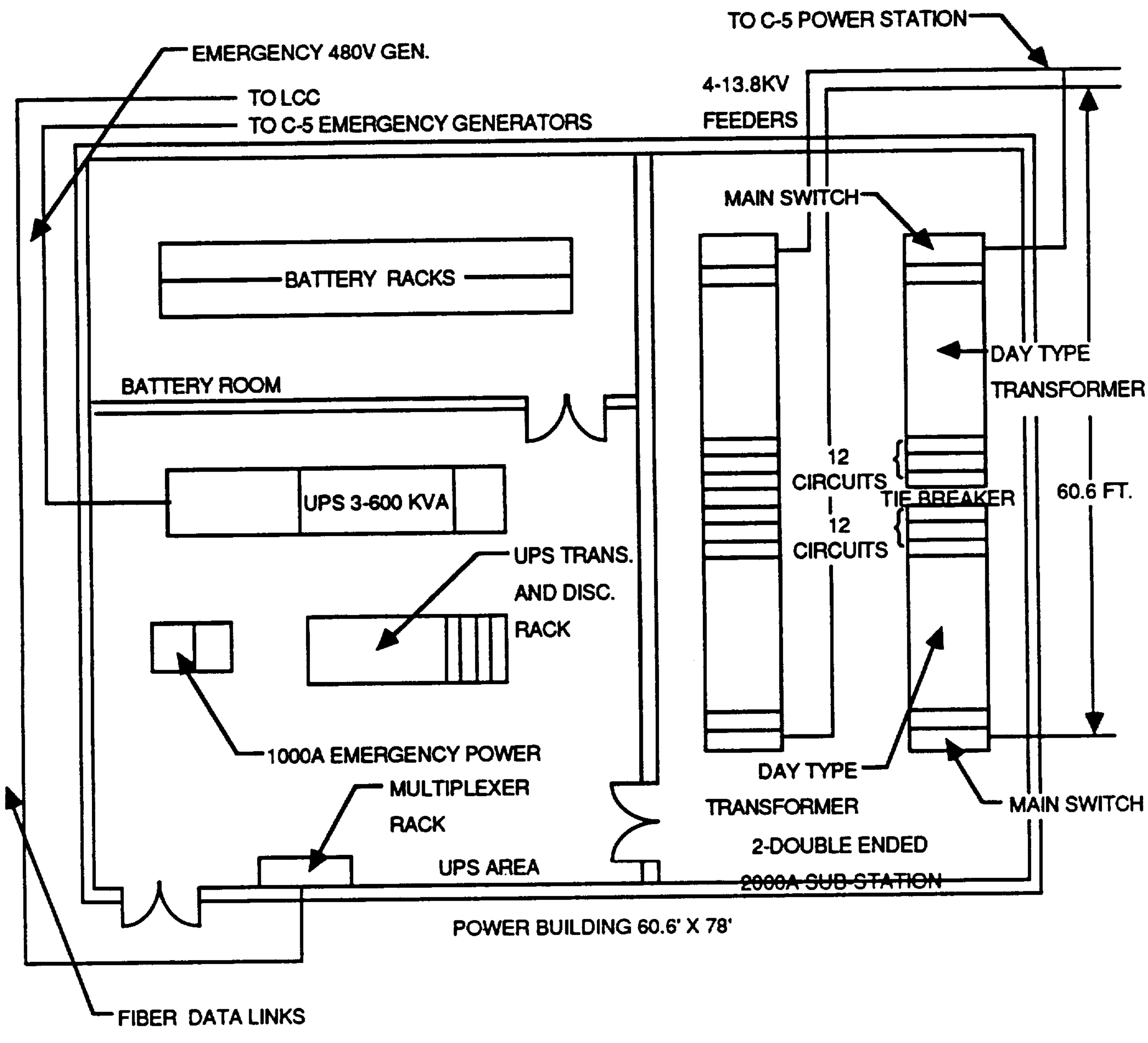


Figure 3.8.1.1-4. ET and LRB Horizontal Processing Facility.

The new platforms for LRB, Orbiter, and ET access would require 120 V, 220 V, 480 V 60-Hz power distribution panels. The power requirements for High Bay 4 would be the same as in High Bays l and 3.

High Bay 4 will require data links to the LCC for the LPS similar to those already in existence in High Bays 1 and 3 with the additional links to support the LRBs.

Requirements for High Bay 3

High Bay 3 will not require additional 60-Hz power substations to support the integration of LRBs. Additions to existing substation capacity and rearrangment of the power distribution system in the High Bay would be required if impacted by platform modifications.

3.8.1.3 Mobile Launcher Platforms

New LRB (Unique Mobile Launcher Platform) MLP-4

A double-ended substation would be required, equivalent to USS-928 on the existing MLPs, for the supply of 110, 220, and 480 V ac 60 Hz. Emergency power on the MLPs is supplied by use of a distribution center which tie through transfer switches to connect to crawler power. No UPS is planned for any MLPs because of vibration problems, but transfer switches will be provided for the connection of critical circuits to the Pad UPS through the substation when the MLP-4 is at the Pad.

The power requirements for a new MLP-4 would be similar to those existing on MLPs 1, 2, and 3. Only those power differences that are required to perform the substitution of SRBs with LRBs would be required. All power requirements will be met by circuit breakers in the substation and distribution panels.

3.8.1.4 Launch Pads A and B

The power requirements for the Pads will be increased with the introduction of a new fuel and expansion of the LOX system. The introduction of an RP1 facility will require new 60-Hz substations for controls and pumps.

AC Power Requirements

The ac power supply for the new fuel storage area and LOX storage area will each require a 1600-amp substation for 60-Hz power. The substation would have a primary input switch fed from a 13.8 kV feeder from the C-5 power station. The substation would consist of the standard 13.8 kV/480 V ac dry-type transformer with secondary distribution circuit breakers.

Each secondary main circuit breaker would be capable of feeding up to 12 secondary circuit breakers. All breakers would be required to be monitored and controlled from the LCC. The secondary breakers would feed all the branch circuits throughout the facility.

Distribution panels with up to 42 circuits, transformers to step down 480 V to 220 V or 120 V, and safety switches for heaters and pumps would be supplied power from the secondary breakers. See Figures 3.8.1.4-1 and 3.8.1.4-2.

3.8.1.5 Launch Control Center (LCC)

There are no facility modifications planned for the LCC which will require changes to the existing power substations to support the LCC.

The addition of 12 new consoles in the Firing Rooms will impose an additional load on the existing LCC UPS units. The UPS power in the LCC is at or near capacity at this time. It is 400 kW units and will need to be replaced with 600 kW units. To change 400 kW to 600 kW units, additional space must be found for their location.

Data links from Pads A and B, VAB High Bay 4, the new MLP-4 parksite, and the new HPF will be required. Space for racks and consoles in the Firing Rooms and the Complex Control Center will be required. Space at each facility for the multiplexer and subsequent distribution racks will also be required.

3.8.1.6 MLP Smart Parksite

The power and data link requirements are based on MLP-1, MLP-2, and MLP-3 requirements. The smart parksite will require the addition of a double-ended substation and two 13.8 kV feeders which will have the capability of being monitored at the LCC. A safety switch will have portable cables that connect to the MLP when it is at the parksite.

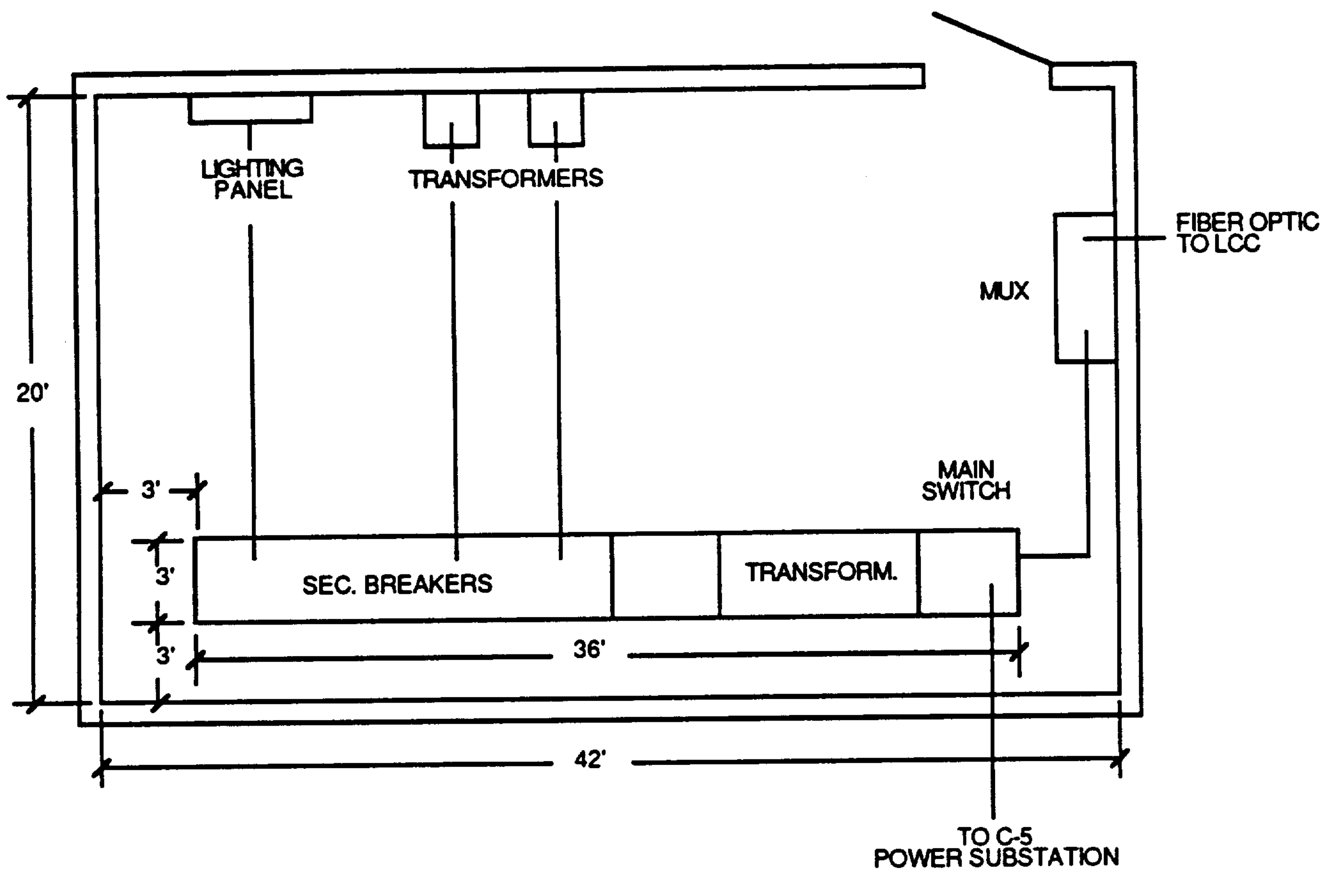


Figure 3.8.1.4-1. Typical Substation Building.

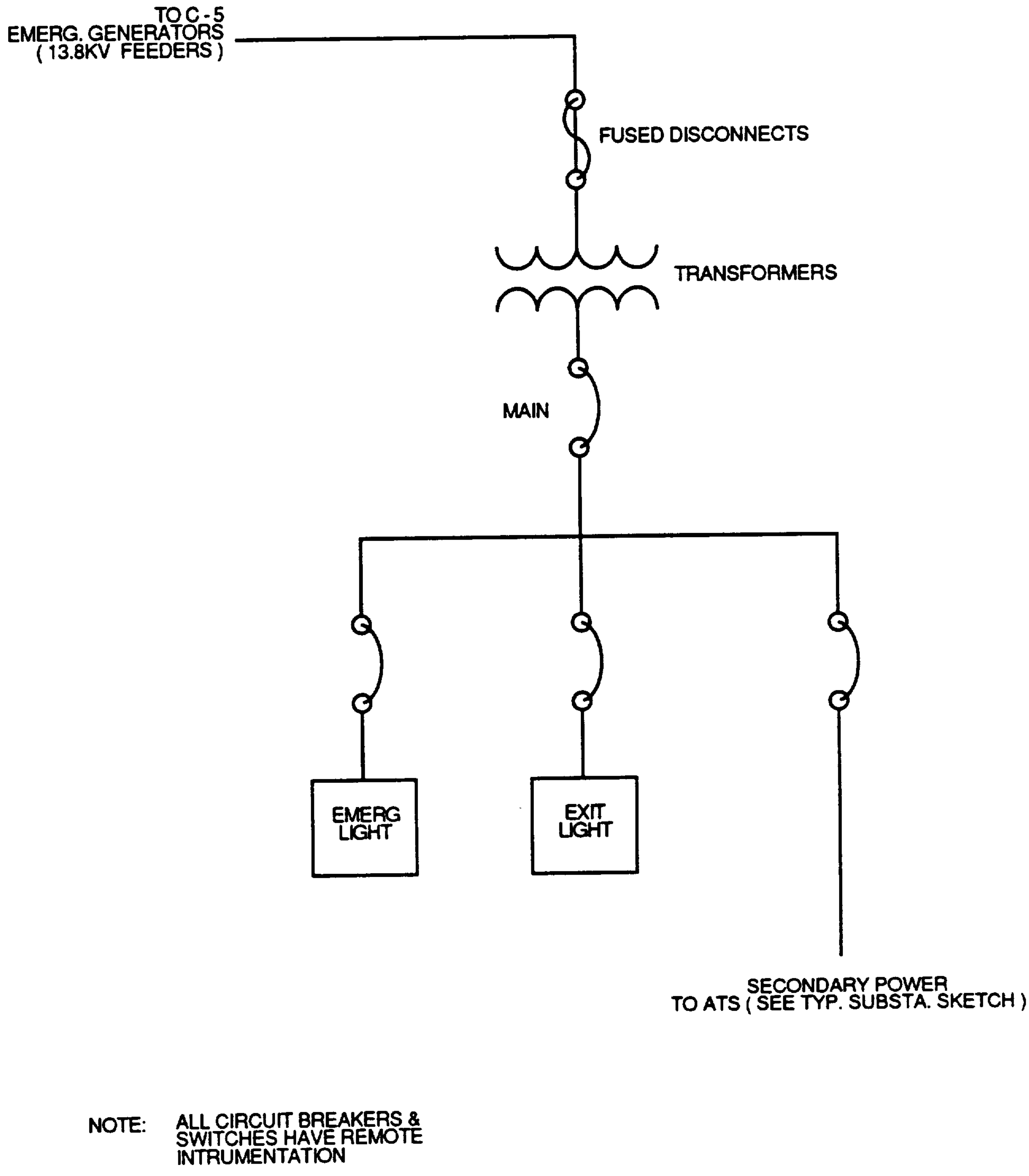


Figure 3.8.1.4-2. Typical Single-Ended Substation.

The MLP parksite will also require one single ended substation and an emergency feeder from the generators at the C-5 substation. This emergency feeder will need to terminate in a safety switch to connect to the MLP with portable cables that have the capability of being monitored at the LCC.

The parksite will require data links to the LCC for the LPS.

Both of the substations, the LPS data links and all distribution racks and transformers will be housed in a building at the parksite with interconnecting cables from the building to the interface panels, including the 9099 interface. See Figures 3.8.1.6.

3.8.1.7 C-5 Substation and Emergency Generator

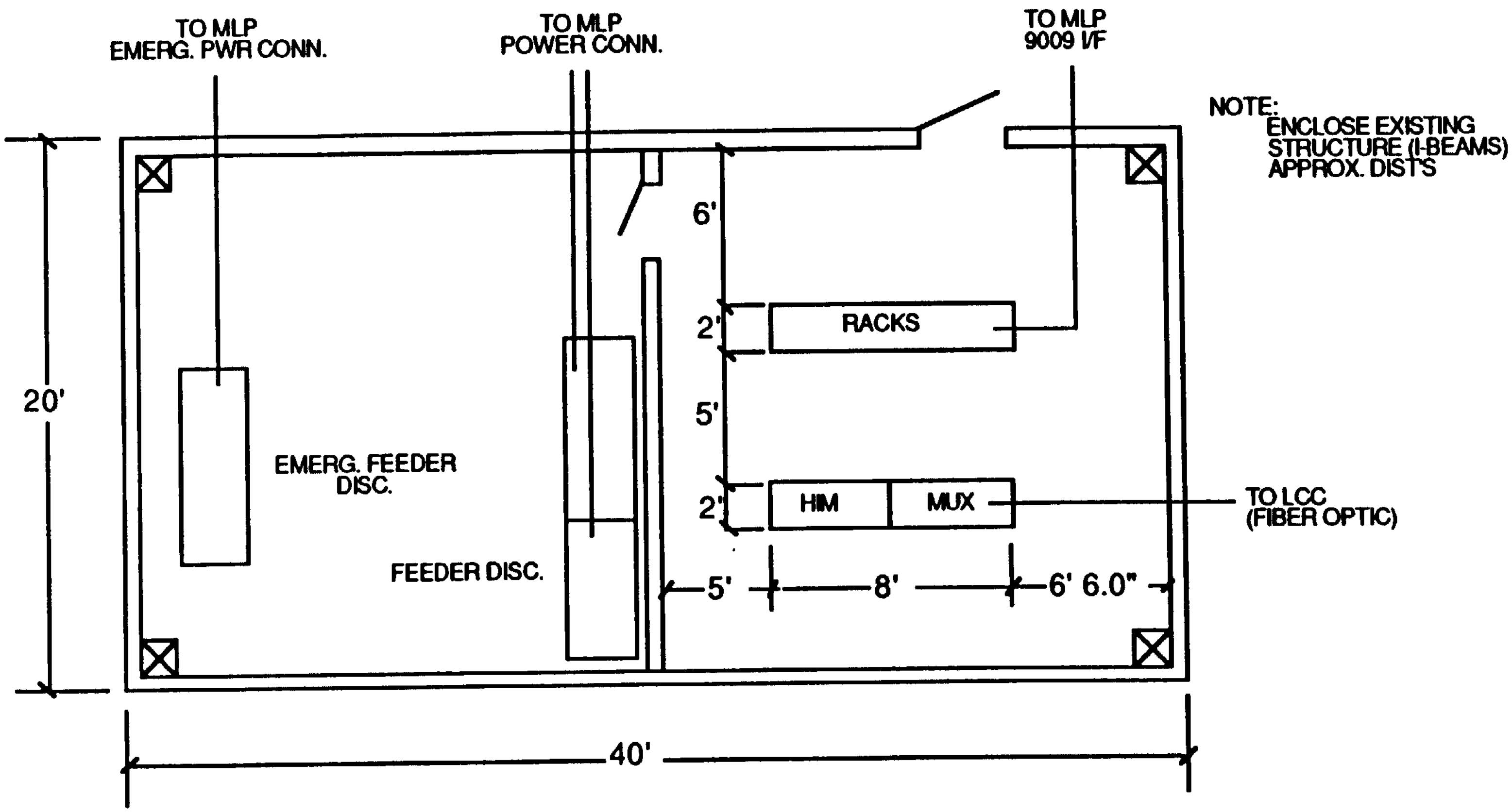
The power requirements of all LC-39 facilities will result in the need for 12 new 13.8 kV feeders from the C-5 substations. The C-5 substation is at or near capacity at this time. Additional switches and transformers will be required in the switchyard to accommodate this new capacity.

There will be five new 480 V ac feeders required from the C-5 emergency generators. Sufficient generator capacity exists to support the additional power loads resulting from the addition of emergency substations. Transformer capacity in the generator building will be exceeded and therefore two new transformers will be required to accommodate the new emergency feeders. The existing cable trenches are at capacity.

To support the addition of new feeders, some new manholes, cable trenches, and duct banks will be required. See Figure 3.8.1.7-1, and 3.8.1.7-2.

3.8.2 Telephone Requirements

The present telephone system in the LC-39 area is at or near capacity. With the addition of the new HPF activation of VAB High Bay 4 as an integration facility, and activation of MLP parksite no. 2, the present telephone system would have to be expanded.



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Figure 3.8.1.6. MLP Parksite #2.

3-3.8 11/11 2:30p

LC-39 POWER REQUIREMENTS				
SITE	FACILITY 60 HZ POWER	EMERGENCY GENERATOR 60 HZ POWER	UPS	FIBER DATA LINKS
LRB AT ET PROCESSING FACILITY	4-13.8KV FEEDERS 2-2000 AMP SUBSTATION (DOUBLE ENDED)	1-480V @ 400 AMP FEEDER	1-600KVA @ 480V	N/R
MLP PARK SITE	2-13.8KV FEEDERS	1-480V @ 400 AMP FEEDER	N/R	20-LCC
PAD A LOX	1-13.8KV FEEDER 1-2000 AMP SUBSTATION	N/R	N/R	3-LCC
PAD A FUEL	1-13.8KV FEEDER 1-2000 AMP SUBSTATION	N/R	N/R	3-LCC
PAD B LOX	1-13.8KV FEEDER 1-2000 AMP SUBSTATION	N/R	N/R	3-LCC
PAD B FUEL	1-13.8KV FEEDER 1-2000 AMP SUBSTATION	N/R	N/R	3-LCC
LCC	N/R	N/R	N/R	54
VAB HI-BAY 4 (ALL NEW)	2-13.8KV FEEDERS	1-480V @ 400 AMP FEEDER	N/R	20-LCC
C-5 POWER STATION C-5 EMERGENCY GENERATORS	12-200 AMP @13.8KV FEEDERS	3-400V @ 480 AMP FEEDERS	N/R	12-LCC

Figure 3.8.1.7-1. LC-39 Power Requirements.

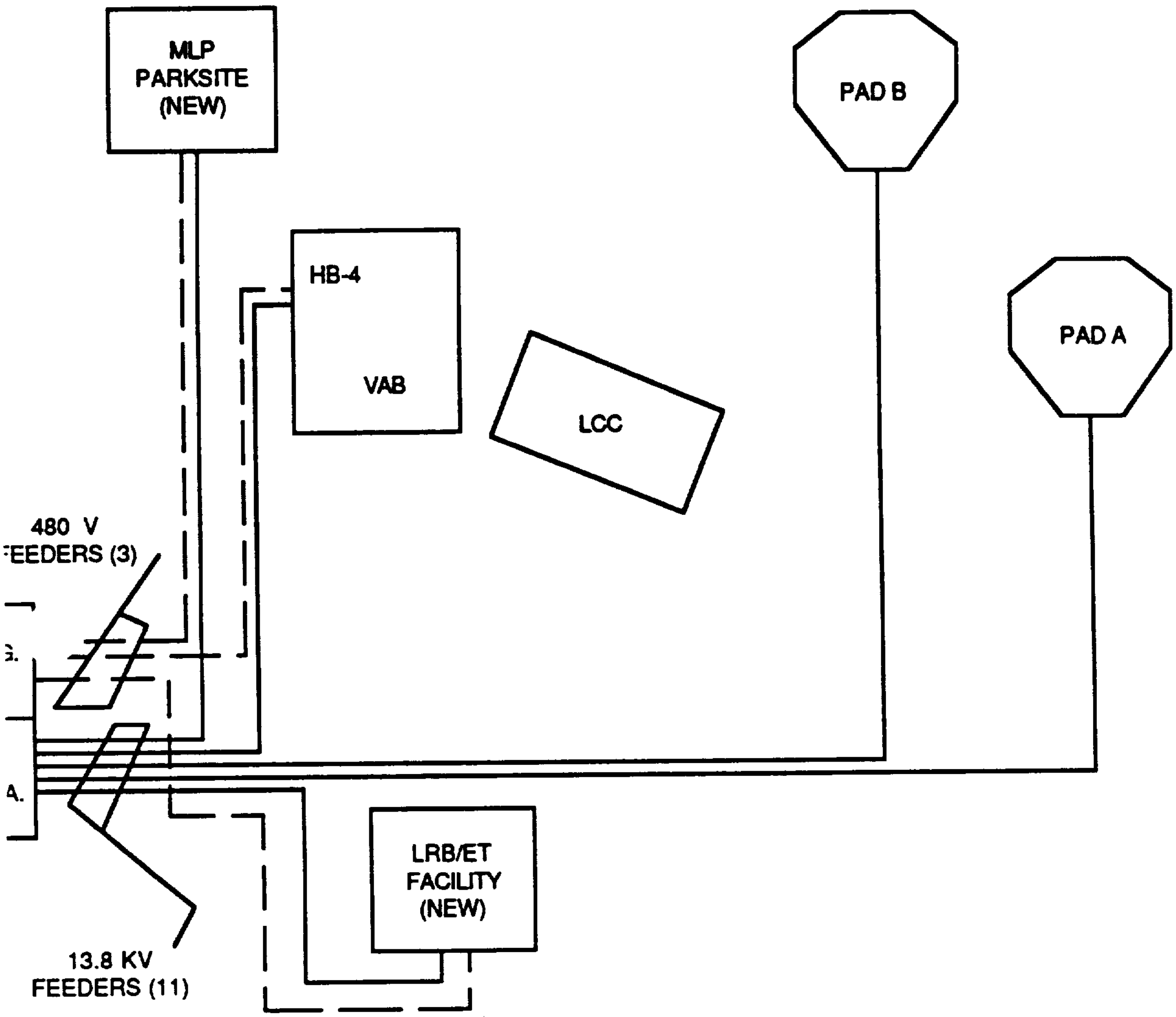


Figure 3.8.1.7-2. LC-39 LRB Power.

3-8.1 10/17 11:30

3.8.3 Operational Intercommunication System (OIS)/Communications (Comm) Requirements

Expansion of the OIS/Comm system will be required because the new HPF, VAB High Bay 4, and MLP parksite no. 2 must be added. It is assumed that the digital OIS planned for implementation will adapt to this expansion easily. Figure 3.8.3 illustrates a fiber optic network for LC 39.

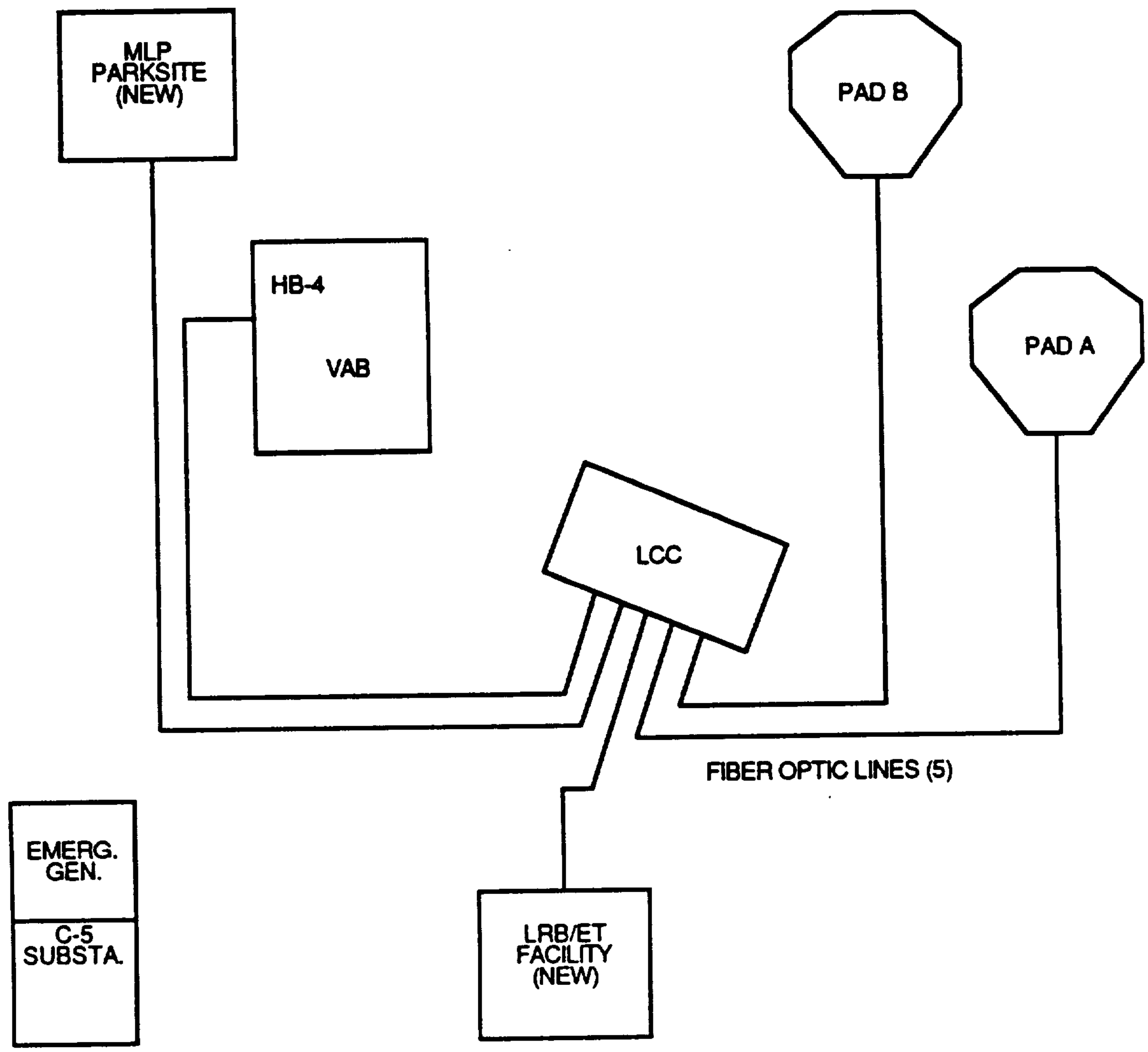


Figure 3.8.3. A Fiber Optic Network For LC-39 LRB Communications.

3.9 FINAL COMMENTS

This section carried the LRB processing flow through the operational station sets, using the current philosophy, to identify LRB facility requirements and impacts. Three visible conclusions are the need for a new ET/LRB Horizontal Processing Facility (HPF), need for a third integration cell and need for a unique MLP for LRB.

The requirement for a HPF stems from operational and activation conflicts and safety issues in the VAB. The requirement for a new integration cell for LRB is driven by not impacting the flight rate and integration schedule in VAB High Bay 3. The new MLP is driven simply because an LRB will not fit on the existing MLP. However an indepth look at the other impacts can lead to additional conclusions.

Starting at the existing LC39 pads, an impact to the flame trench and flame deflectors is presented. Although the flame deflections may be fabricated to be an extension of the trench, withstand direct exhaust impingement and be refurbished, it will incur expensive processing costs. Alternative to the re-occurring cost would be a modification of the flame trench concrete or a new pad for the alternate vehicle configuration.

The existing Orbiter/ET umbilicals also present philosophy issues. The ET H2 vent line for example is a drop mechanism which is provided structural integrity by the fluid flex hose the umbilical mechanism and pyrotechnic bolt loads are sensitive to the loads imposed by the flex. Hose and vehicle excursions. The redesigns required by the LRB diameter will increase this sensitive using the present design configuration and operational mechanism. A new design for the vent arm should be considered with the ET being changed to accommodate an optimum design solution.

The GOX vent arm as an example is impacted by the boosters greater than 170 ft. in length. Again a viable redesign is applicable to the ET which would eliminate the GOX vent arm.

In both cases the solution for the umbilicals impacts should consider reducing cost, maintenance, launch preparation (hook-up) and provide acceptable loads for the ET interface.

LRB forward access requirements above the RSS roof and existing SRB platform (EL217 ft.) results in greater structural requirements for the RSS beyond the capacity of the existing truck

driver. The LRB contractor must not require access greater than 121 ft. from the bottom of the booster skirt.

The impacts to the flame trench/deflectors, umbilical mechanisms highlights two basic conclusions: integration of LRBs must consider changes to the ET configuration and possible a new launch pad for alternate Shuttle configurations may be required.

Following through with the consideration of a new pad, the opportunity for developing an alternative integration process is available. The alternative process may include stack at pad or horizontal integration. The alternatives may decrease the processing timelines, recurring cost, manpower requirements and enhance safety concerns (crane/configuration, working at heights, movement of flight hardware).

VOLUME III

SECTION 4

LRB LAUNCH SUPPORT EQUIPMENT DEFINITION

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LAUNCH SUPPORT EQUIPMENT DEFINITION

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SECTION 4

LAUNCH SUPPORT EQUIPMENT DEFINITION

This study product defines the Launch Support Equipment (LSE) required to support an LRB at the Pad or on the MLP. The study will cover LRB holddown on the MLP and interface umbilicals.

4.1 LRB HOLDDOWN SYSTEM CONCEPTS

This section presents two holddown concepts for LRBs. The presented concepts provide for a support/soft-release system for post-Space Shuttle Main Engine (SSME) ignition that will have the least impact on the present Space Shuttle Vehicle (SSV) ground support systems, while minimizing anticipated shock and deflection effects of the launch load transients. A description of the existing SRB holddown system is provided to establish a baseline.

4.1.1 SRB Holddown Posts Description

The SRB holddown posts have been designed to minimize the following launch-induced effects:

SSME buildup load transient
Occurs during ignition and thrust buildup of the SSMEs, which are offset relative to each SRB axis of bending. Consequently, the SRBs deflect in a cantilever mode and are allowed to flex through one full cycle of response, bending over to a maximum and back to a minimum before SRB ignition.

Lift-off load transient
Occurs when the SRBs are ignited and the Orbiter is released from its holddown posts. The sudden release, combined with the large accelerative force of the SRBs, causes longitudinal loads.

Umbilical tracking
Occurs during ignition and thrust buildup of the SSMEs. The subsequent translation of the STS induces large umbilical tracking excursions.

The SRB support/release system includes the following elements:

- Holddown post casting
- Holddown stud
- Pyro-release/holddown nut
- Shims
- Eccentric bushing
- Spherical bearing (puck)
- SRB shoe

4.1.2 LRB Holddown Post Concept

This concept modifies the existing SRB holddown post system to provide a soft release feature. The static load on the LRB should, essentially, be the same as for the SRBs. However, the post LRB ignition-induced transients would differ from those of the SRBs, principally because the LRBs will not accelerate as quickly as the SRBs. Figure 4.1.2-1 shows a conceptual arrangement of the holddown posts. That arrangement satisfies the plus-pattern engine concepts provided by MMC configurations and the GDSS LOX/RP-1 pressure-fed configuration. The other General Dynamics configurations obviously cannot be satisfied without extensive MLP modifications. Discussions hereafter are therefore only with respect to the plus-pattern engine configuration.

Major design changes should not be required for the existing SRB holddown post casting or support umbilicals if the weight and stiffness of the LRBs approximate those of the SRBs.

No ground/flight interface component modifications should be required if the design of the aft skirts of the LRB are similar to those of the SRBs.

Some release modifications are required to the present holddown post assembly to alleviate the differences between the present SSME build-up and lift-off load transients and the proposed SSME buildup and lift-off load transients. This could be accomplished by extruding a die through a preshaped billet of malleable material to provide a slow, damped release of the LRBs. (Figures 4.1.2-2 and 4.1.2-3 show the components of the holddown post.) To accomplish this:

- Tension the holddown stud (same as for the SRB).
- Place the lower retainer over the pyro-nut.

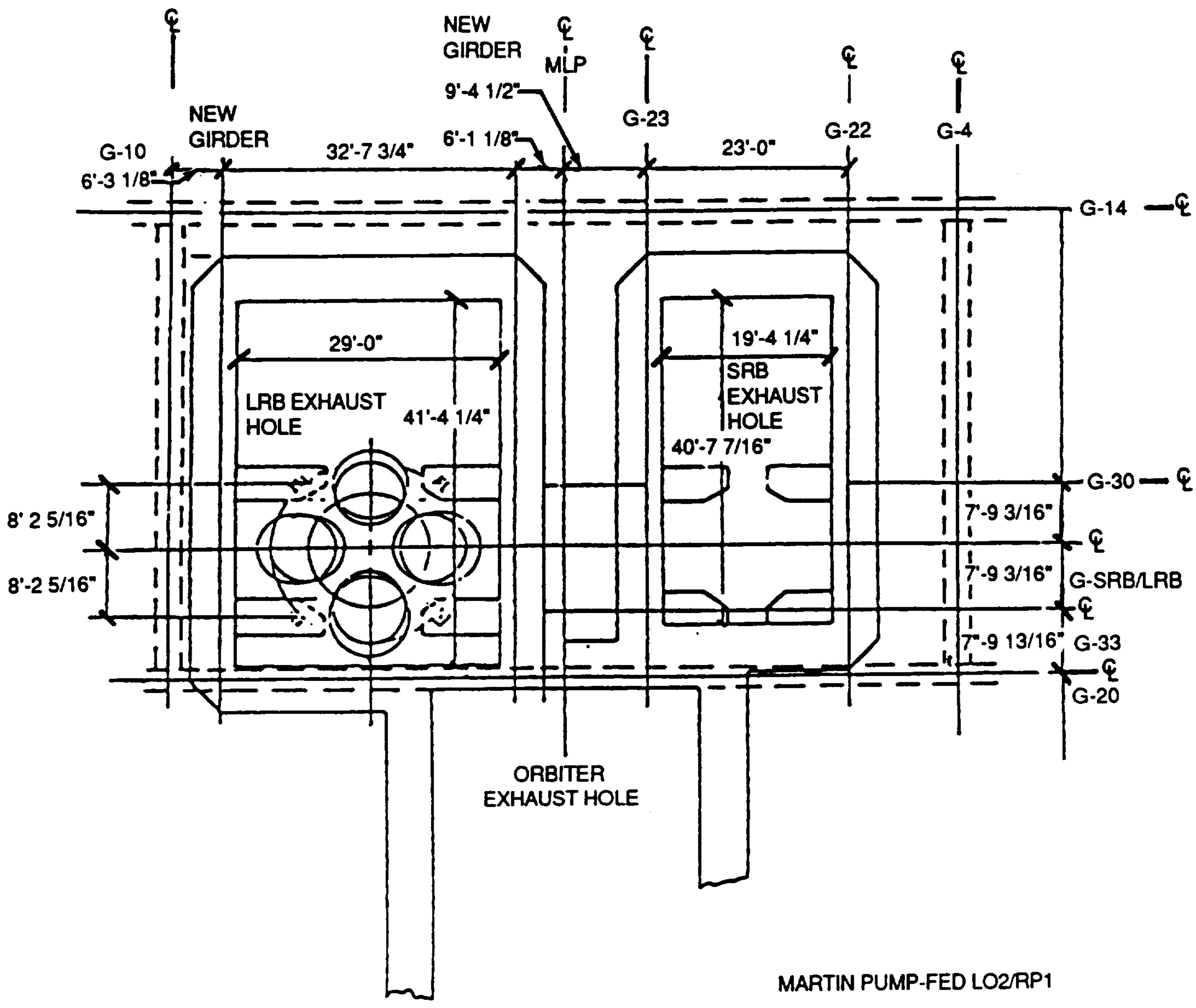
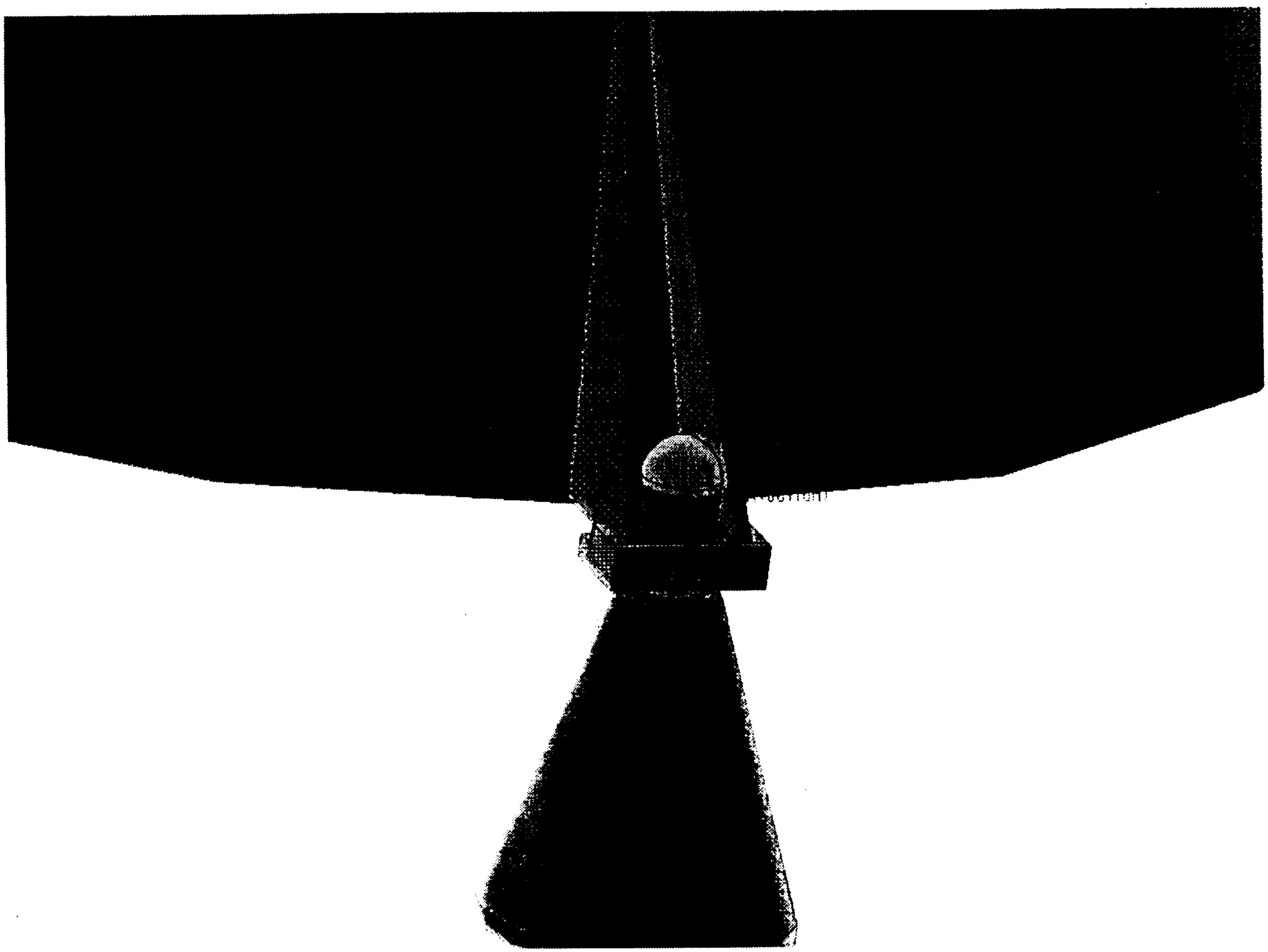


Figure 4.1.2-1. Holddown Post/Haunch Arrangement (MMC).



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Figure 4.1.2-2. Holddown Posts with Soft Release (MMC).

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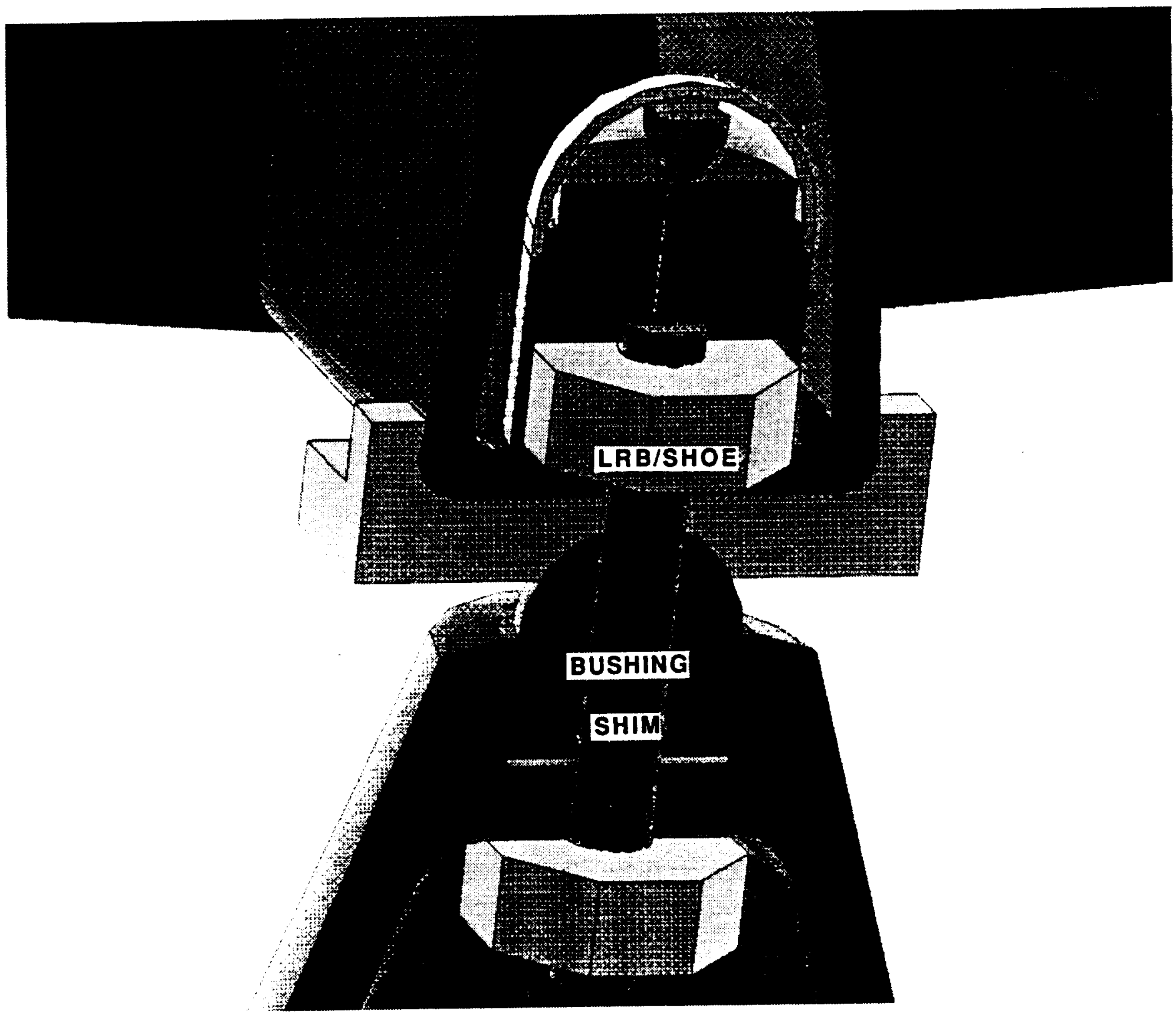


Figure 4.1.2-3. Holddown Post Cross Section.

- Attach the lower retainer to the LRB foot.
- Place the billet on top of the lower retainer.
- Thread the die to the holddown stud.
- Attach the upper retainer to the lower retainer.

When the LRB engines are started, the restraint force is released from the pyro-nut and the load path proceeds from the holddown stud to the die, from the die to the billet, which in turn rests on the lower restraint, and finally to the LRB foot. At this point the ascending Orbiter causes the die to be extruded through the billet, thus providing a "soft" release. After the extrusion process the holddown stud -- with the attached die -- falls into the hollow of the holddown post, while the pyro-nut and the other elements above it are captured between the upper and lower restraint housing to be recovered along with the LRB casing.

4.1.2.1 Conclusions/Recommendations

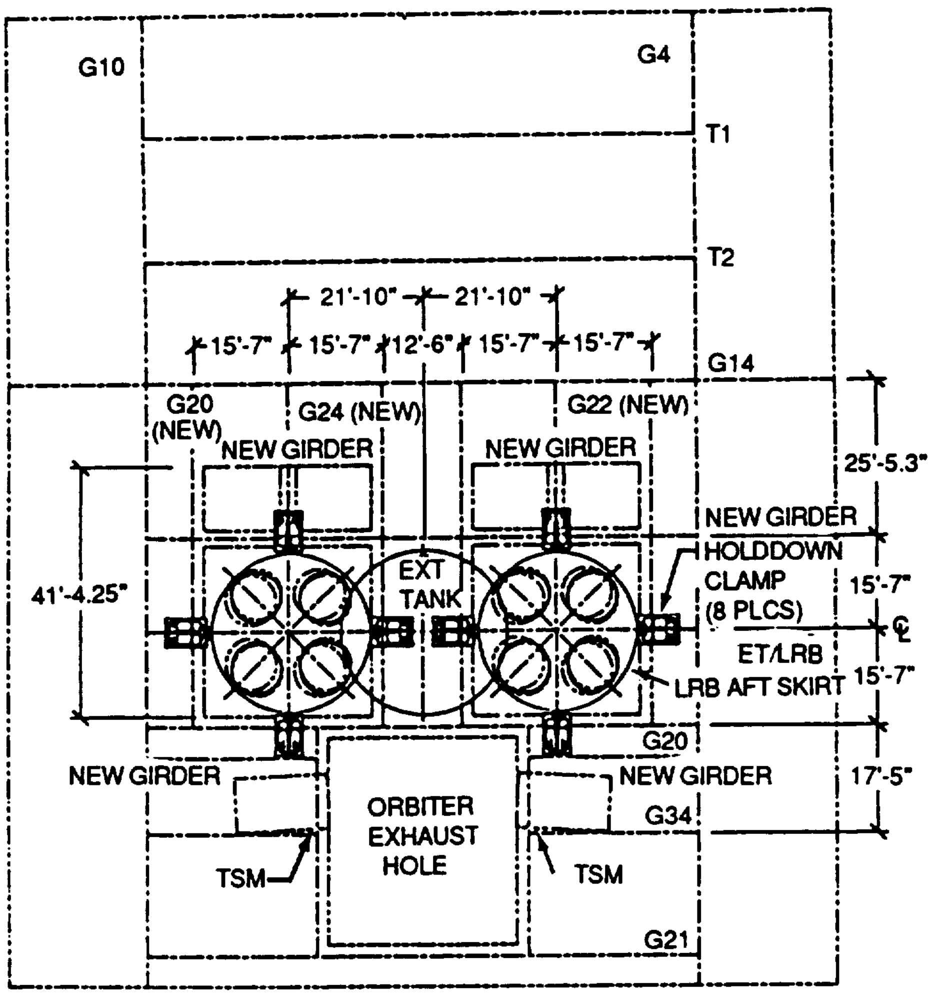
The holddown post stud is probably the only element from the present configuration that could not be utilized in this proposed LRB support/release system. Also, the entire holddown post stud tensioning procedure and tensioning equipment should remain virtually unchanged.

The General Dynamics Corporation cross-pattern configurations would require many expensive and time-consuming modifications to the MLP to provide a girder across the flame hole.

It is feasible that the present support holddown post assembly can be modified per this report's proposal to provide a soft release capability. It can then be used as a prototype for Launch Equipment Test Facility (LETF) testing to establish the type and size of the die and billet for the amount of lift-off damping required.

4.1.3 LRB Holddown Mechanism Concept

This holddown mechanism concept is based on the holddown clamp system used on the Apollo Saturn rocket, (Figure 4.1.3-1 shows a conceptual arrangement of the holddown mechanism) which provides a soft-release feature. As can be seen, it satisfies the General Dynamics cross-pattern configuration, but obviously not the plus-pattern configuration.



PLAN - MLP GDSS LO2/RP-1 PUMP FED LRB

Figure 4.1.3-1. Holddown Mechanism Arrangement (GDSS).

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The system consists of the following parts (see Figure 4.1.3-2):

- Holddown casting/housing
- Holddown arm
- Counterweight and die
- Holddown stud bolt and pyro-nut
- Extrusion pins (2 a) and nuts
- LRB Aft skirt shoe

The holddown clamps will be installed on the 0-Level of the MLP, eliminating the need for the haunches used on the present holddown posts for the SRBs.

The aft skirt shoe can be designed to provide +/- X inch adjustment height for leveling the LRB during stacking. The face of the holddown casting (facing aft skirt) is angled to follow an assumed drift angle equivalent to the current SRB drift angle of 17 degrees.

Holddown clamping force is provided by the stud bolt/pyro-nut and the two extrusion pins through the counterweight/die and the holddown arm to the LRB aft skirt support column.

It is assumed that static loads on the LRBs are the same as the present SRBs. However, the ignition-induced loads of the LRBs would be different from that of the SRBs because the former will not accelerate as fast as the SRBs. It is for this reason that a soft release method is preferable on LRBs during launch.

At T-0, the pyro nut is exploded. As the main and booster engines build up the thrust for a lift-off, all the transient loads are transferred from the aft skirt via the hold down arm to the extrusion pins, which in turn are held by the nuts against the holddown casting. The extrusion pins are made up of a malleable material. At this point, the ascending Space Shuttle Vehicle causes the arm and counterweight/die to extrude the extrusion pins, providing a "soft" lift-off. The counterweight ensures that the holddown arm clears the LRB aft skirt after the extrusion process has been effected. All debris (pyro-nut, stud bolt, extrusion pins) are contained inside the casting. There will be no pyro nut and extrusion pin debris that will go up with the LRBs, as was the case with the Saturn rockets and currently with the SRBs.

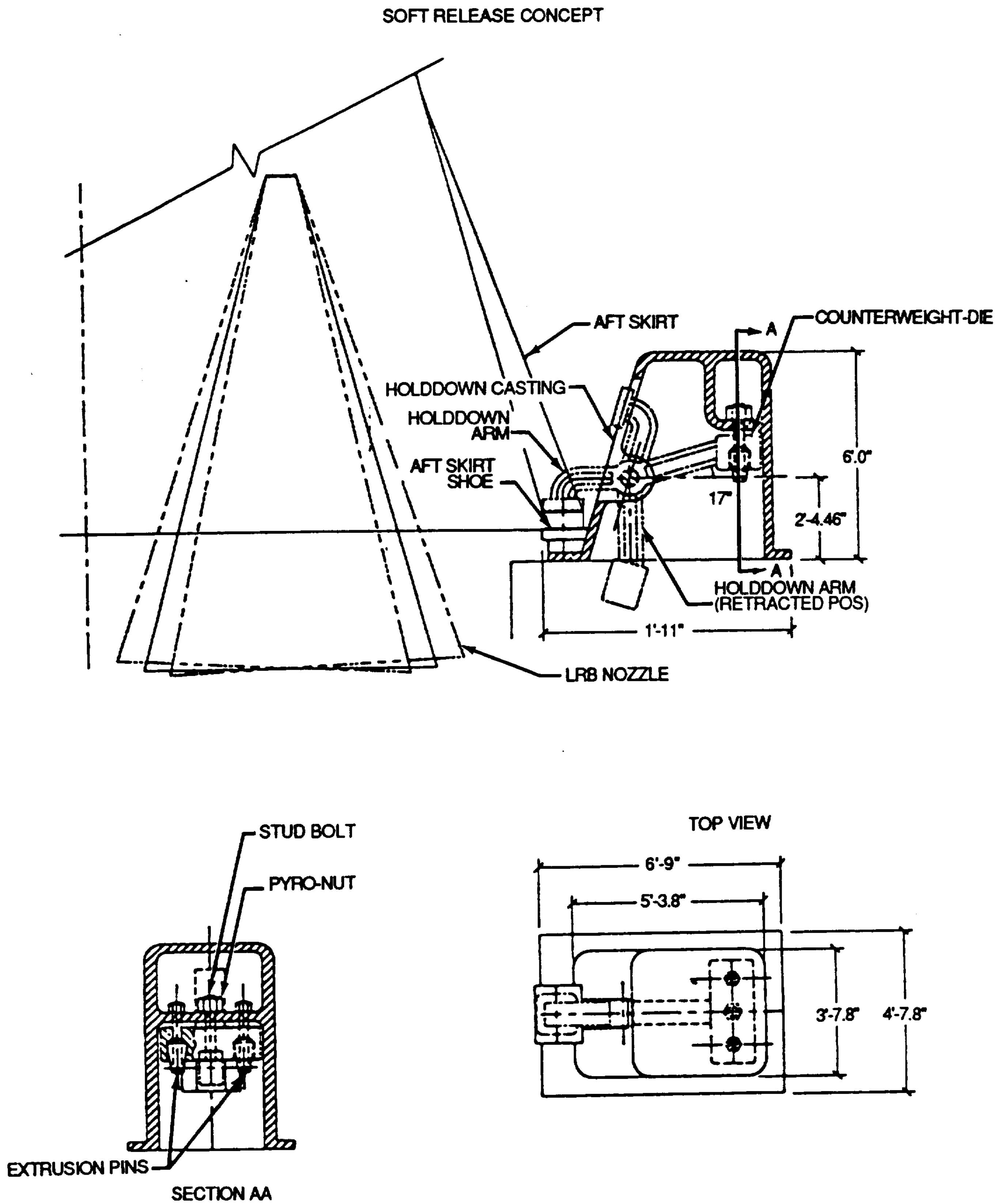


Figure 4.1.3-2. Holddown Mechanism (GDSS).

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4.1.3.1 Conclusions/Recommendations

The proposed concept can be ideally used on the General Dynamics booster nozzle configuration: nozzles clocked at 45 degrees. Further studies are required on how present MLPs can be modified to use this holddown system. The tensioning procedure in this proposed holddown system will be similar to the present procedure being used with the SRB holddown posts.

4.2 LRB UMBILICAL REQUIREMENTS

This section presents the conceptual requirements for new umbilicals which will be required for LRBs.

4.2.1 Ground Rules And Assumptions

Since the excursions for an LRB/SSV are not defined at this time, it will be assumed that existing on-Pad vehicle excursions would be unchanged. A T-O umbilical would not be required for RP-1 fuel fill and drain operations since it is a storable propellant which can be loaded in advance of launch operations (OMI S0007). All umbilicals would accommodate necessary electrical/electronic connectors and pneumatics in addition to their being a vital element of the required propellant (LO2, LH2, LCH4) fill and drain operations. All flight propellant fill/drain and vent umbilical plates would be located in LRB skirt area. This assumption eliminates the requirement for swing arms and towers. All LRB configurations provide for a LOX vent to atmosphere.

4.2.2 New Cryogenic Umbilical Requirements

Each of the six LRB concepts would require, at the least, an LO2 fill and drain umbilical. The GDSS LO2/LH2 LRB concept would also require LH2 fill/drain and vent umbilicals for each LRB. Likewise, the GDSS LO2/LCH2 LRB concept would require LCH4 fill/drain and vent umbilicals for each LRB in addition to the LO2 umbilicals. All the new umbilical GSE systems would require complete LETF validation and qualification testing. (See Section 3, Paragraph 3.7.)

Additional umbilical capability would be required for pneumatic and electrical/electronic services such as propellant pressurization, purging, instrumentation, power, etc. However, due to potential vehicle launch drift, the location of existing GSE (such as the Orbiter TSM umbilicals), the appar-

ent location of the flight umbilical plates in the LRB skirts, and available MLP/Pad space (especially adjacent to the LRBs) would be at a premium. Therefore, it is assumed that, from an umbilical perspective, there would be left hand and right hand LRBs and that the propellant fill/drain umbilicals would be designed to accommodate these additional service requirements.

The conceptual LRB umbilical LSE systems would have to be the T-O lift-off type, either similar to the Tail Service Mast (TSM) depicted in Figure 4.2.2-1 that was used for the Saturn launch vehicle or a smaller version of the existing Orbiter TSM umbilical system shown in Figure 4.2.2-2.

Regardless of which of the six LRB concepts is selected, extensive modification to the MLP would be required to provide for the installation of the new service masts and associated propellant and pneumatic lines, instrumentation cabling, etc.

4.2.3 Cryogenic Vent Umbilical Requirements

Although an assumption was made that vent interfaces for the cryogenic propellants would be provided in the skirt area and LOX would vent to atmosphere, there is the possibility that umbilicals might be located at upper elevations.

The requirement to capture H2 and CH4 because of their hazardous nature exists. The LRB configuration using LH2 and LCH4 may have umbilicals which would require swing arms and towers. Figures 4.2.3-1 and 4.2.3-2 illustrate concepts for such a requirement. This requirement would entail the modification of the Fixed Service Structure (FSS) to support the umbilical vent swing arm for the left LRB and provide a tower on the east side of the Pad to support the umbilical vent swing arm for the right LRB.

4.2.4 RP1 Umbilical Requirements

RP-1 is a storable propellant which can be loaded in advance of launch operations. A portable service mast is recommended to provide access to the LRB RP-1 umbilical. The ground umbilical plate mast can be removed prior to launch. Figure 4.2.4 illustrates this concept.

4.2.5 Conclusions/Recommendations

Figure 4.2.5-1 shows that from the new umbilical perspective, the LO2/LH2 and the LO2/LCH4

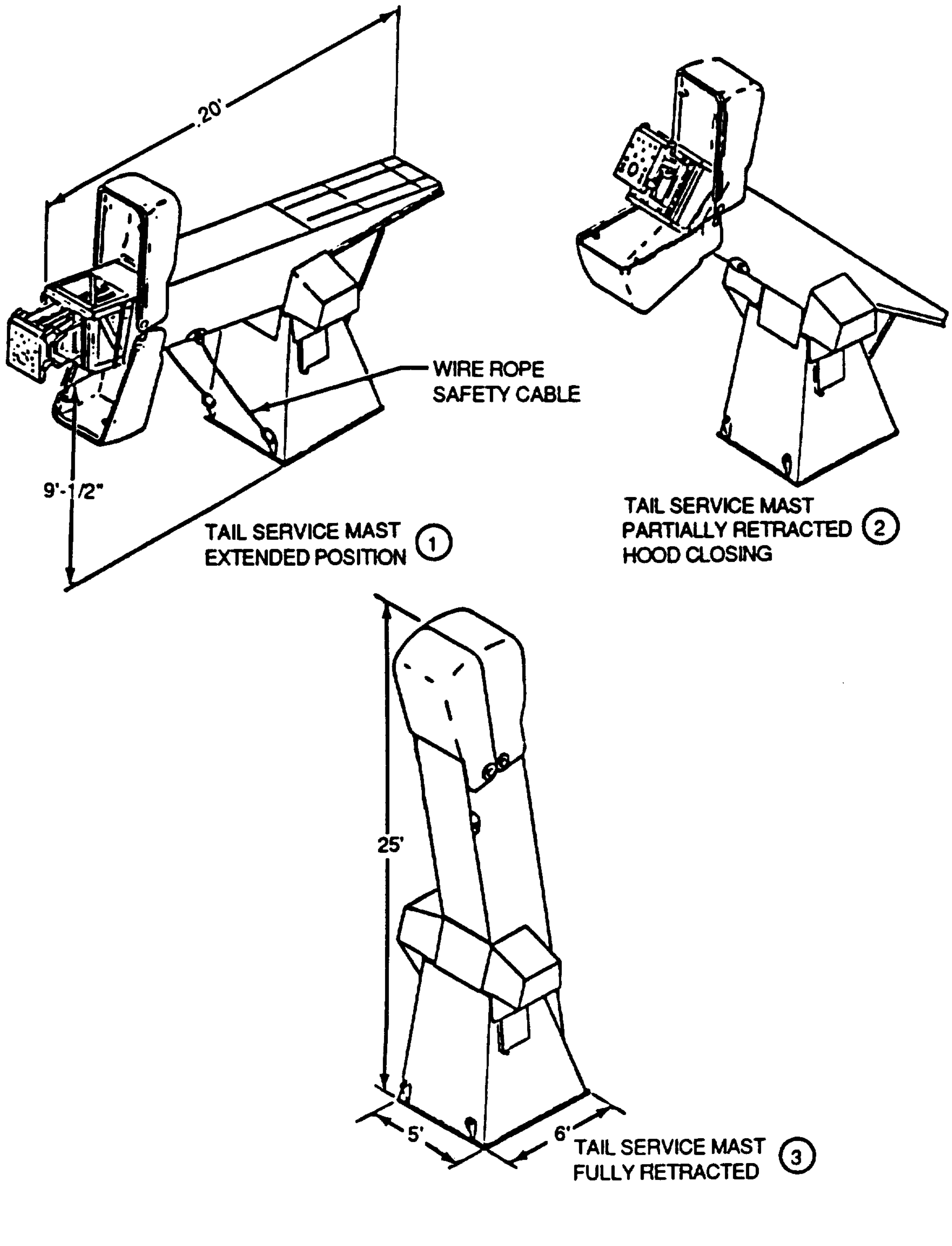


Figure 4.2.2-1. Tail Service Mast Umbilical. (Saturn Type)

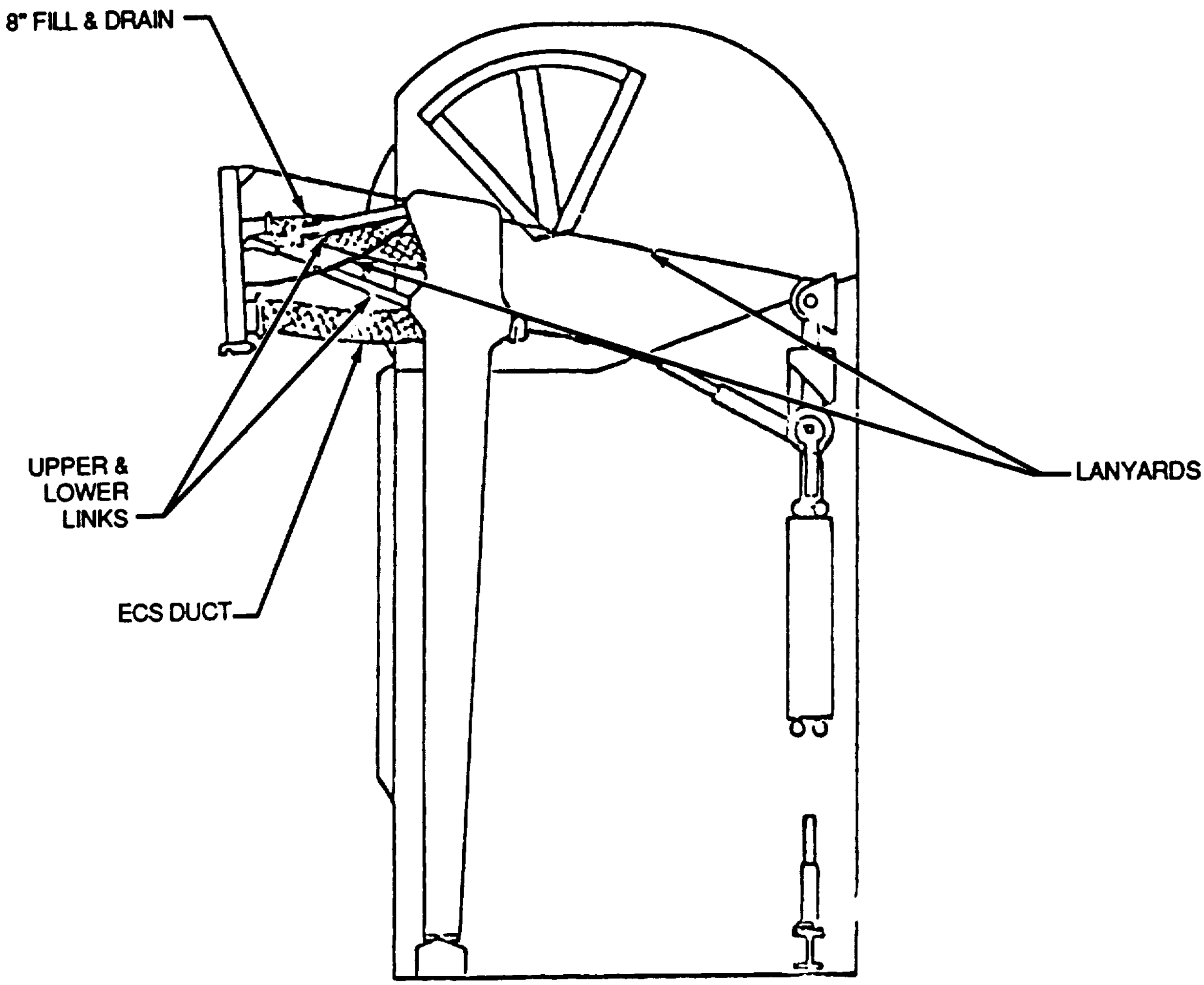


Figure 4.2.2-2. Orbiter TSM.

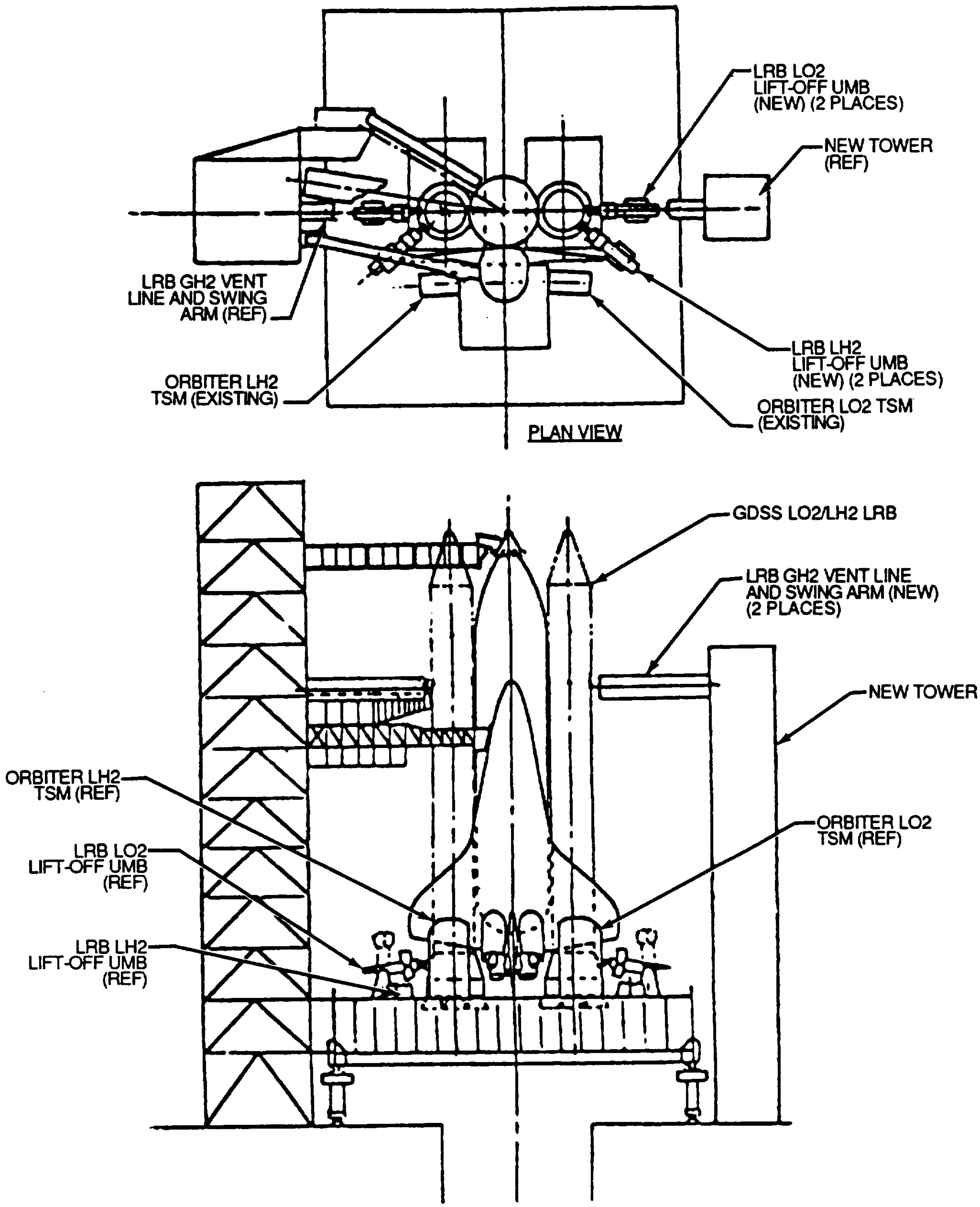


Figure 4.2.3-1. LRB Umbilicals, GDSS LO2/LH2 Concept.

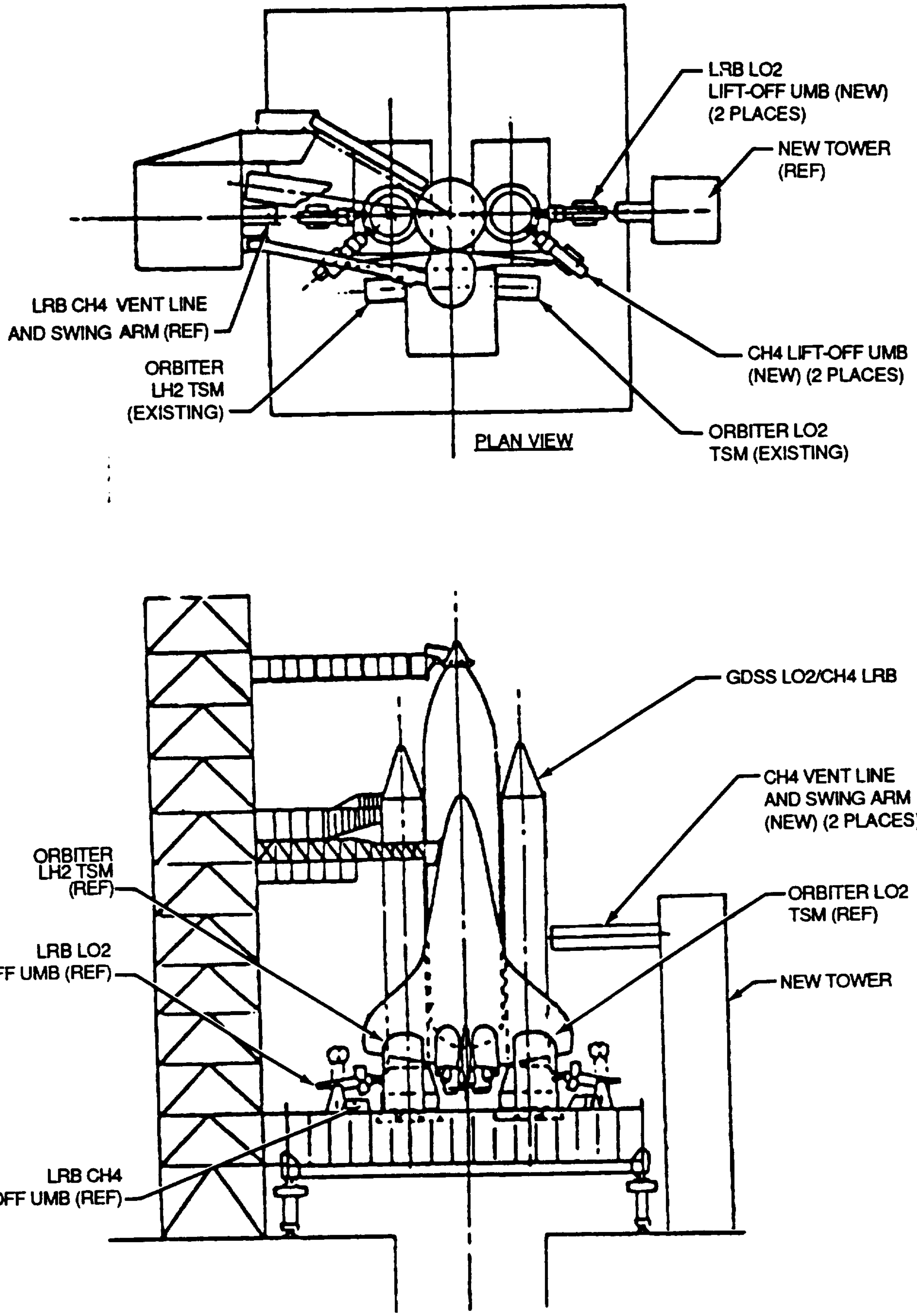


Figure 4.2.3-2. LRB Umbilicals, GDSS LO2/CH4 Concept.

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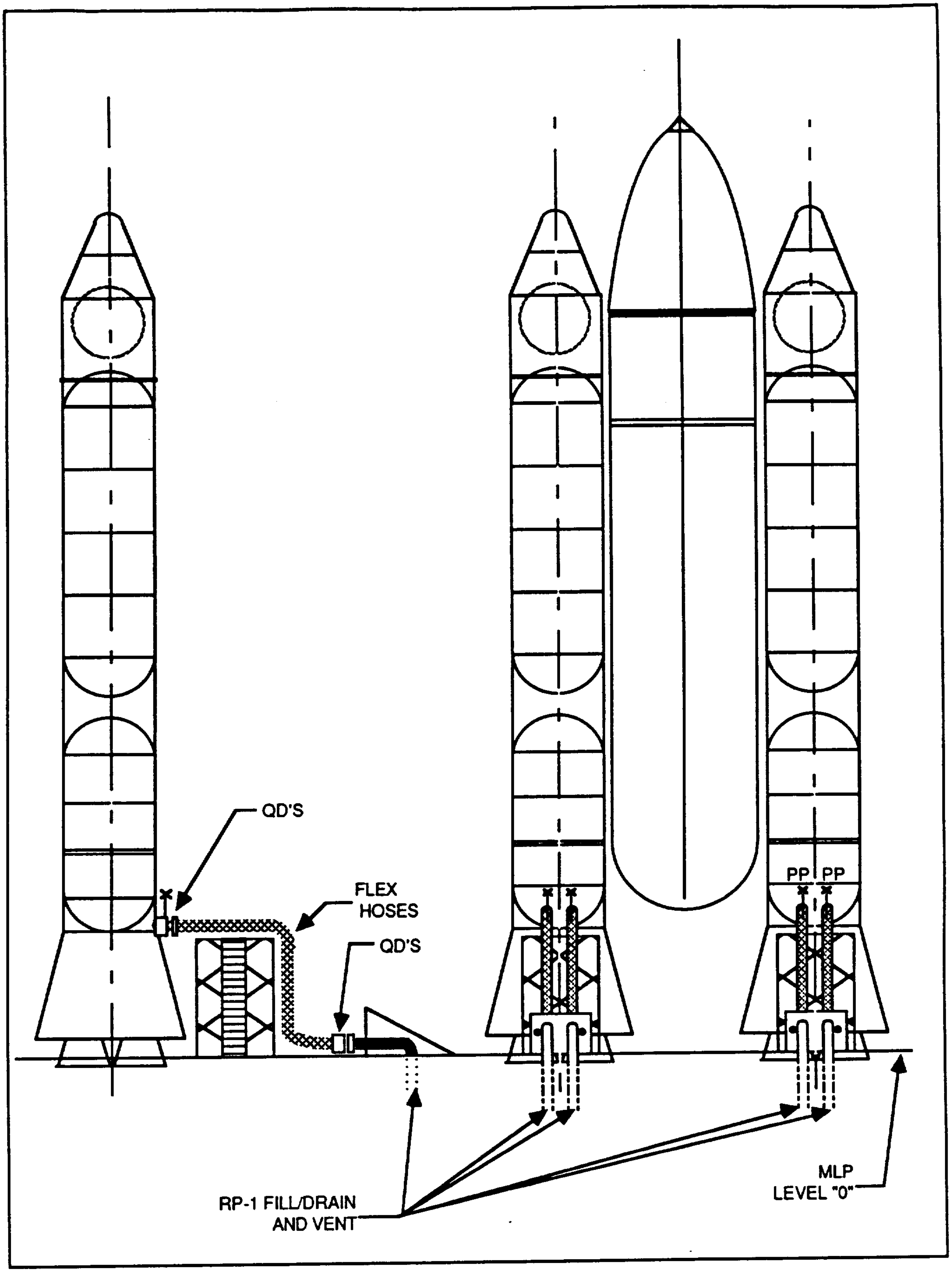


Figure 4.2.4. RP-1 Portable Service Mast/Umbilical Concept.

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LRB / LAUNCH UMBILICAL SYSTEMS SUMMARY							
LRB OPTION / IMPACT	MM LO2 / RP-1 PUMP	MM LO2 / RP-1 PRESSURE	GDSS LO2 / RP-1 PUMP	GDSS LO2 / RP-1 PRESSURE	GDSS LO2 / LH2	GDSS LO2 / CH4	REF FIGURES
NEW LO2 LIFT-OFF UMB FOR EACH LRB	X	X	X	X	X	X	4.2.2-1 4.2.3-1
NEW LH2 LIFT-OFF UMB FOR EACH LRB					X		4.2.2-1 4.2.3-1
NEW CH4 LIFT-OFF UMB FOR EACH LRB						X	4.2.2-1 4.2.3-1
NEW GH2 VENT LINE & SWING ARM FOR EACH LRB (IF REQUIRED)					X (NOTE)		4.2.3-1
NEW CH4 VENT LINE & SWING ARM FOR EACH LRB (IF REQUIRED)						X (NOTE)	4.2.3-2
NEW GH2 VENT LINE TOWER & FSS MOD (IF REQUIRED)					X (NOTE)		4.2.3-1
NEW CH4 VENT LINE TOWER & FSS MOD (IF REQURED)						X (NOTE)	4.2.3-2
NEW POWER / INST. FOR EACH LRB	X	X	X	X	X	X	-
NEW RP-1 SERVICE MAST	X	X	X	X			4.2.4

NOTE: AFT VENTS WILL UTILIZE THE LIFT-OFF UMBILICALS

Figure 4.2.5-1. LRB/Launch Umbilical Systems Summary.

LRB concepts will each require far more new equipment and modifications to existing GSE than any of the LO2/RP-1 pressure or pump-fed LRB concepts (illustrated in Figure 4.2.5-2). The requirement for new vent umbilical and swing arm systems, associated FSS modifications, and a new support tower structure can be eliminated by requiring the GDSS LO2/LH2 and LO2/LCH4 LRB concepts to have aft skirt vent umbilicals.

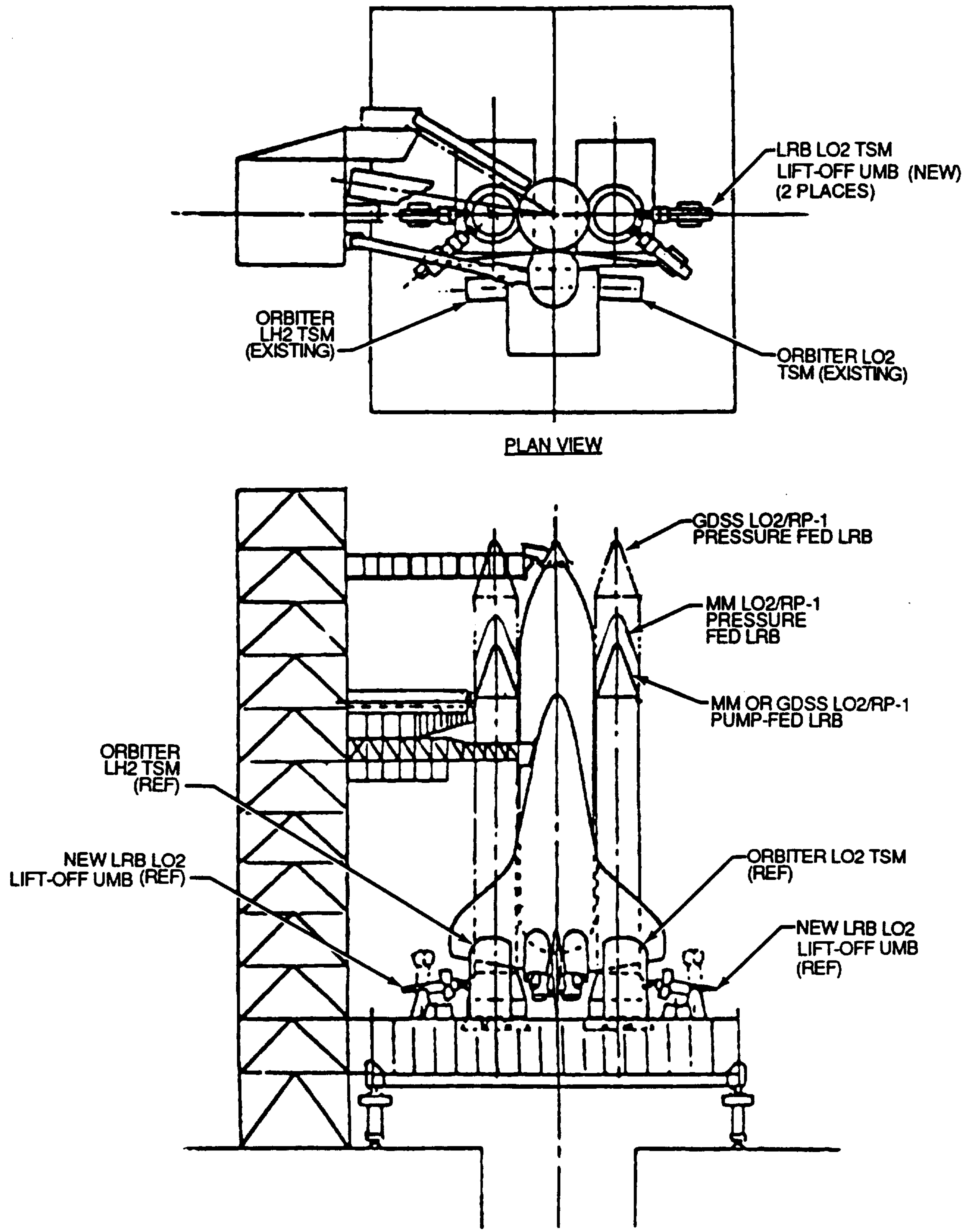


Figure 4.2.5-2. LRB Umbilicals, MMC & GDSS LO2/RP-1 Pressure and Pump-Fed Concepts (4).

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VOLUME III

SECTION 5

LRB GROUND SUPPORT EQUIPMENT DEFINITION

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SECTION 5

LRB GROUND SUPPORT EQUIPMENT DEFINITION

This study product defines the Ground Support Equipment (GSE) required to support an LRB at KSC. The study covers all equipment and systems necessary to process an LRB and launch an LRB/STS.

5.1 ET/LRB HORIZONTAL PROCESSING FACILITY GSE

As described in Section 3.1 of Volume III, Section 3, the processing requirements of LRBs and External Tanks (ETs) will require an assortment of GSE to be provided in the ET/LRB Horizontal Processing Facility (HPF). This section will define the GSE needed.

5.1.1 HPF Fluid GSE Requirements

This section defines the fluid GSE required for the facility to service LRB tanks and engines and the ET.

5.1.1.1 ET/LRB Facility Fluid GSE

A source for high pressure gases and compressed air to supply the ET/LRB Horizontal Processing Facility will be required. Fabrication of GSE will be based on existing Facility GSE design at the Orbiter Processing Facility (OPF).

The OPF pneumatic system utilizes three permanently installed panels outside the building. These panels monitor, control, and distribute GN2, GHe, and a hazardous air purge at various pressures, temperatures, and flow rates to the High Bays. The facility GSE for the new HPF will consist of similar equipment.

The facility will have its own supply of high pressure gases and compressed air system for hazardous purge and shop tools. A separate area to house the 6000-psig high pressure gas storage tanks for GHe and GN2 will be located as near to the CCF/VAB GHe pipeline as possible and the Big Three GN2 pipeline. The GHe will be supplied from the CCF, while the GN2 will be supplied by

a Big Three pipeline. A utility annex will be required at the HPF to house the air compressor and other utilities.

Gaseous Nitrogen Primary Regulation Panel

This panel will be installed outside the building. The panel will receive 6000 psig GN2 supply from the HPF high pressure storage area and regulate it to 3000 psig and 750 psig for distribution throughout the area. The panel will be electrically connected to the Control Room computer system and will be similar to the existing S70-0675-1 at the OPF.

Gaseous Helium Primary Regulation Panel

This panel will also be installed outside the building. The panel will receive 6000 psig GHe from the HPF high pressure storage area and regulate it to 6000 psig and 3000 psig for distribution throughout the area. The panel will also be electrically connected to the Control Room computer system and will be similar to the existing S70-0695-1 at the OPF.

Hazardous Air Regulation Purge Panel

This panel will also be installed outside the building. It will receive 125 psig air from the HPF Utility Annex and regulate it to 50 psig for distribution to explosion-proof pneumatic panels, electrical boxes, communication boxes, and for other miscellaneous requirements. The panel will be provided with a redundant system which regulates 750 psig GN2 to 40 psig and branches it to the 50 psig air outlet. The 750 psig GN2 supply will come from the GN2 primary regulation panel. The panel will be similar to the S70-0888-1 at the OPF.

5.1.1.2 LRB Processing Fluid GSE

The ground support system for servicing the LRB tanks will consist of a network of pneumatic panels to regulate and distribute facility helium and nitrogen gases for pressurization, monitoring, safing, maintenance of tank pressures, vent valves functional checks, and various leak checks associated with LRB processing. Figure 5.1.1.2 illustrates a proposed configuration for the new LRB GSE.

Helium Pressurization and Checkout Panel

This panel will service the LRB propellant tanks for both storage and checkout cells by regulating facility supply to 3000 psig for the LRB vent valve actuation panels and deliver a constant GHe flow rate for maintaining positive pressures during checkout and leak test operations. In addition,

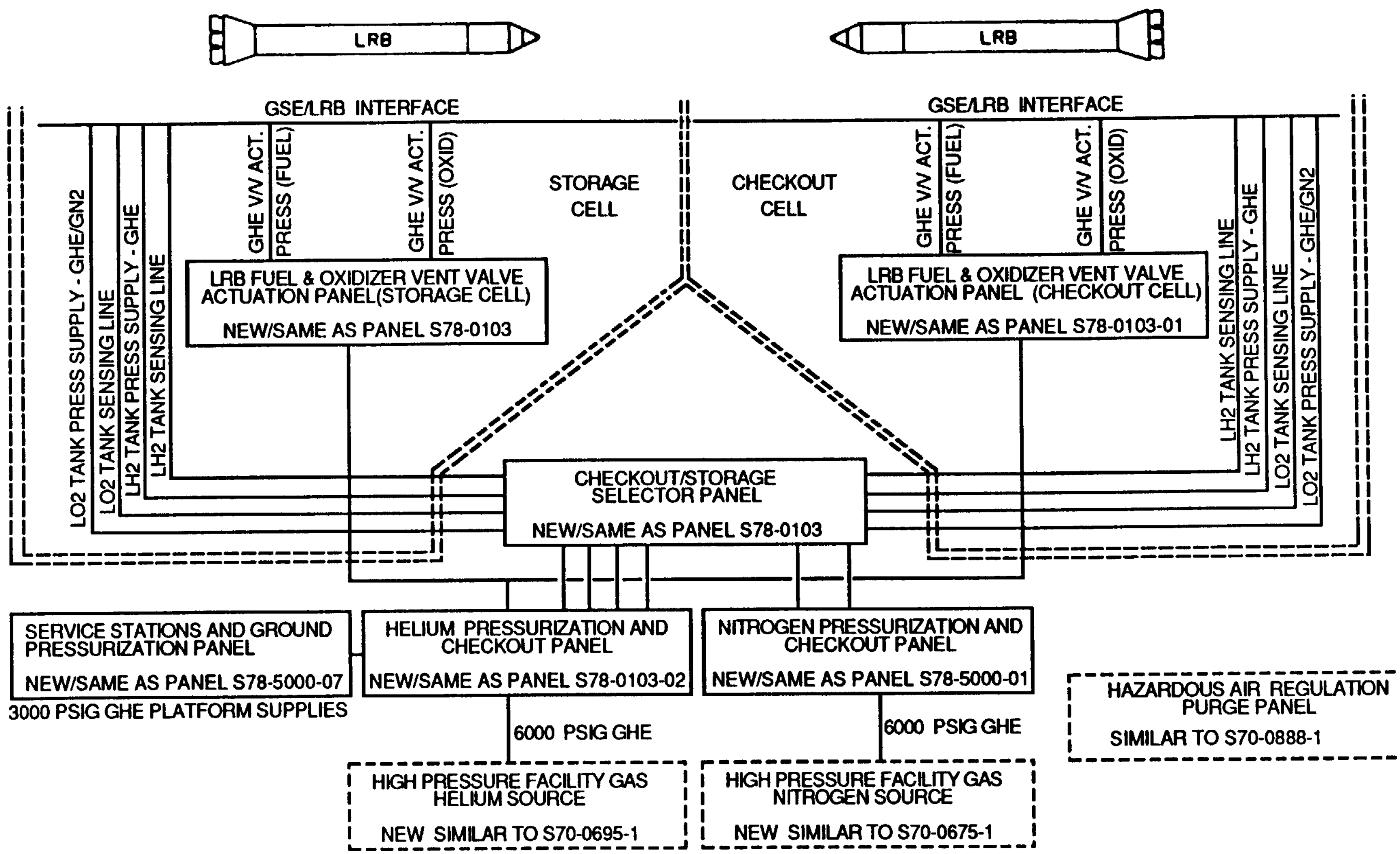


Figure 5.1.1-2. Pneumatic Flow Diagram of GSE for LRB Tank Processing.

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the panel will monitor tank pressure and provide, via computer link indication, overpressure protection by remotely controlling the LRB propellant tank vent valves. The panel will also provide a 3000-psig supply for contingency facility service and ground pressurization panel.

This equipment will be new but similar to equipment currently utilized for ET processing. (PMN S78-0103-02)

LRB Fuel and Oxidizer Vent Valve Actuation Panel (Storage Cell)
This panel will provide helium to the pneumatically operated fuel and oxidizer vent valves for actuation purposes during LRB storage and checkout processing.

This equipment would be new yet similar to equipment utilized for ET processing. (PMN S78-0103-04)

LRB Fuel and Oxidizer Vent Valve Actuation Panel (Checkout Cell)
This panel will provide helium to the pneumatically operated fuel and oxidizer vent valves for actuation purposes during LRB storage and checkout processing. The vent valve actuation pressures are not defined.

This equipment will be new but similar to equipment utilized for ET processing. (PMN S78-0103-01)

Helium Service Stations and Ground Pressurization Panel
Service stations will provide the capability to utilize 3000-psig helium for facility purposes and for contingency ground pressurization for either the fuel or oxidizer tanks.

This equipment will be new but similar to equipment utilized for ET processing. (PMN S78-5000-07)

Checkout/Storage Selector Panel
This panel will be utilized to select the pressurization and monitoring system for servicing the propellant tanks in either the storage and checkout cell.

This equipment will be new but similar to equipment utilized for ET processing. (PMN S78-0103)

LRB Nitrogen Pressurization and Checkout Panel

This panel will service the LRB oxidizer tanks for both storage and checkout cells by regulating facility supply to 3000 psig to deliver a constant GN2 flow rate for maintaining positive pressures during checkout and leak test operations. In addition, the panel will monitor tank pressure and provide, via LPS indication, overpressure protection by remotely controlling the LRB oxidizer tank vent valves.

This equipment will be new yet similar to equipment currently in use for ET processing. (PMN S78-5000-01).

5.1.1.3 LRB Engine Servicing Fluid GSE

The Ground Support System for engine servicing and checkout will consist of a network of pneumatic panels to regulate and distribute GHe and GN2. Figure 5.1.1.3 illustrates the proposed configuration.

GN2/GHe LOX Checkout Panel

This panel will be a purged enclosure-type box. The panel will be located near the aft section of the LRB where it is needed. The panel will receive 3000 psig GHe from the GHe primary regulation panel and regulate to various pressures and flow rates to meet propulsion system test and checkout requirements.

The panel will also receive 750 psig GN2 supply from the GN2 primary regulation panel and regulate to required pressures for leak checking and miscellaneous usage. This panel will be similar to the existing S70-0695-2 in the OPF.

GN2/GHe Fuel System Checkout Panel

This panel will be a purge enclosure-type box. It will be located near the LRB aft section. The panel will receive 6000 psig GHe from the GHe primary regulation panel and regulate to various pressure and flow rates for GHe bottle fill and various tests and checkout requirements of the LRB propulsion and engine systems. The panel will also receive 750 psig GN2 supply from the GN2 primary regulation panel and regulate to required pressures for leak checking and miscellaneous usages. The panel will be electrically connected to the LPS system and will be similar to the existing S70-0695-2 in the OPF.

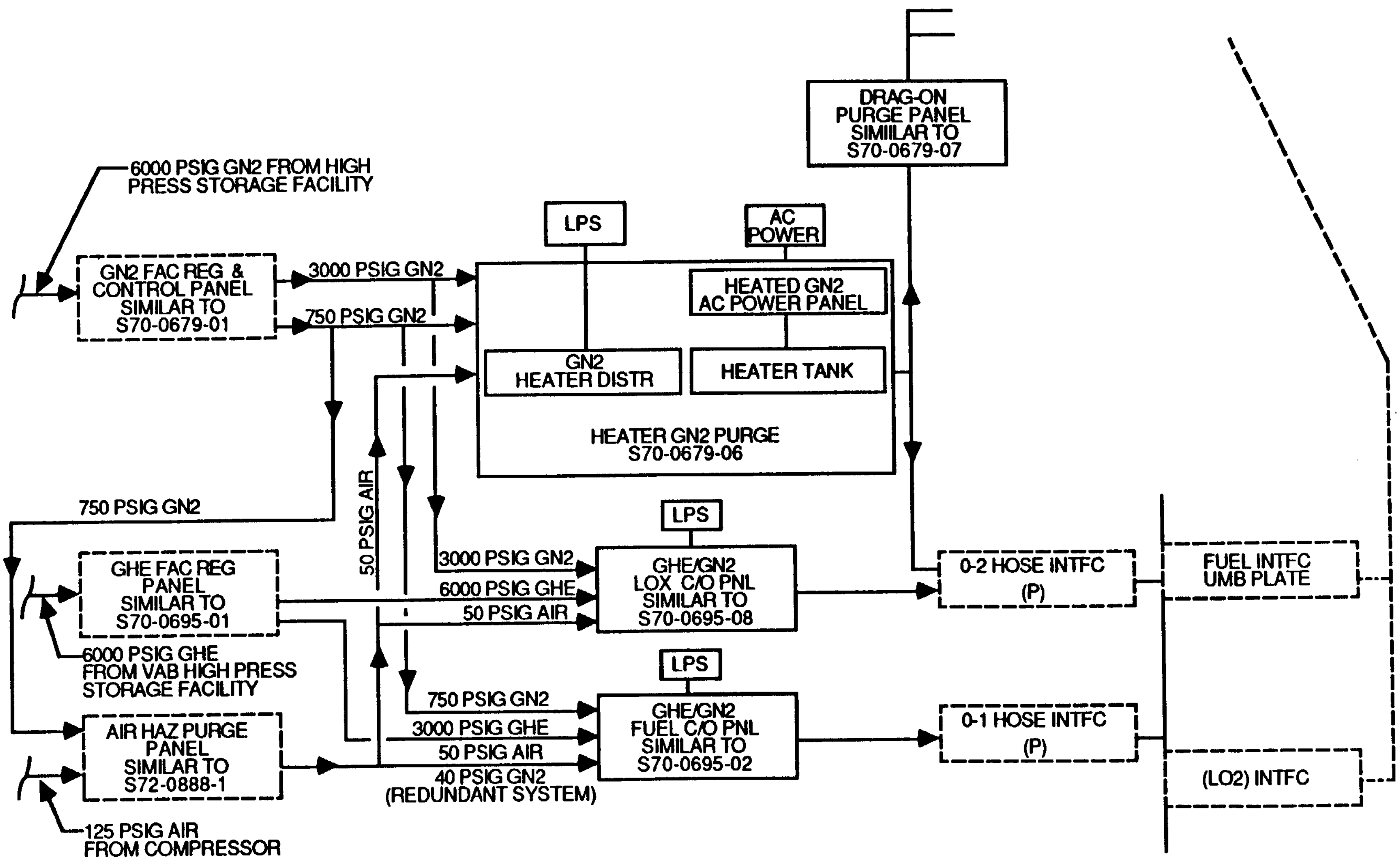


Figure 5.1.1.3. LRB Engine Serving GSE

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GN2 Heater Purge Regulation Panel

The panel will consist of a pressure regulation circuit, tank heater controller, and electrical distributor. The panel will receive 3000 psig GN2 from the GN2 primary regulation panel, which will be regulated/heated to 765 psig at 40 to 185 °F for distribution to purge, dry, and functionally checkout the propulsion system. The 750 psig GN2 received will be used for valve actuation; 50 psig air received from the panel for the hazardous air purge will be used to purge heater tank electrical terminal housing, heater controller, and terminal distributor. Panel will be electrically connected to LPS system. The panel will be similar to the S70-0679-6 in the OPF.

Drag-on Purge Panel

The panel will be portable. It will receive 765 psig GN2 at 40 to 180 °F from the heated GN2 heated purge regulation panel and regulate it to various pressures for engine drying, purging, and checkout. The panel will be similar to the S70-0679-07 in the OPF.

To supplement the propulsion system servicing panels, portable panels will be required for miscellaneous tests as follows:

- Portable Regulation panel for functional checkout, similar to the C70-0743-XX
- Flow Tester for various engine flows/leakage or functional checkout tester, similar to the C70-0903/C70-0904/C70-0908
- Equipment to inspect internal condition of engine components, similar to C70-0907
- Engine leak and functional checkout equipment, similar to the C70-0914
- Engine flush and drying equipment
- Helium Leak Detector, similar to the C72-0127-08
- Pressure Regulator Panel, similar to the A34-329-301.
- Varian Mass Spectrometer, similar to the Z70-0023.

5.1.1.4 ET Processing Fluid GSE

The ground support system for servicing the External Tank (ET) will consist of a network of pneumatic panels to regulate and distribute facility helium and nitrogen gases for pressurization, monitoring, saving, maintenance of tank pressures, vent valves functional checks and various leak checks associated with processing. Figure 5.1.1.4 illustrates a proposed system configuration.

ET Helium Pressurization and Checkout Panel

This panel will service the ET propellant tanks for both storage and checkout cells by regulating facility supply to 3000 psig for the ET vent valve actuation panels and by delivering a constant GHe flow rate for maintaining positive pressures during checkout and leak test operations. In addition, the panel will monitor tank pressure and provide, via LPS indication, overpressure protection by remotely controlling the ET propellant tank vent valves. The panel also will provide a 3000-psig supply for contingency facility service and ground pressurization panel. This equipment is currently located in the VAB (PMN S73-0103-02) and could be relocated to the new HPF.

ET Fuel and Oxidizer Vent Valve Actuation Panel (Storage cell)

This panel will provide helium to the pneumatically operated fuel and oxidizer vent valves for actuation purposes during ET storage and checkout processing. The panel will simulate the Pad ET vent valve actuation panel. It will provide to the LH2 vent valve with 750 +/-50 psig and the LOX vent valve with 775 +/- 25 psig. This equipment exists in the VAB (PMN S78-0103-04) and can be relocated to the new facility.

ET Fuel and Oxidizer Vent Valve Actuation Panel (Checkout Cell)

This panel will provide helium to the pneumatically operated fuel and oxidizer vent valves for actuation purposes during ET storage and checkout processing. The panel will simulate the Pad ET vent valve actuation panel. It will provide the LH2 vent valve with 750 +/-50 psig and the LOX vent valve with 775 +/- 25 psig. The equipment is currently located in the VAB (PMN S78-0103-01) and can be relocated to the new facility.

Helium Service Stations and Ground Pressurization Panel

Service stations will provide the capability to utilize 3000 psig helium for facility purposes and contingency ground pressurization for either the fuel or oxidizer tanks. The equipment is currently located in the VAB (PMN S78-5000-07) and could be relocated to the new facility.

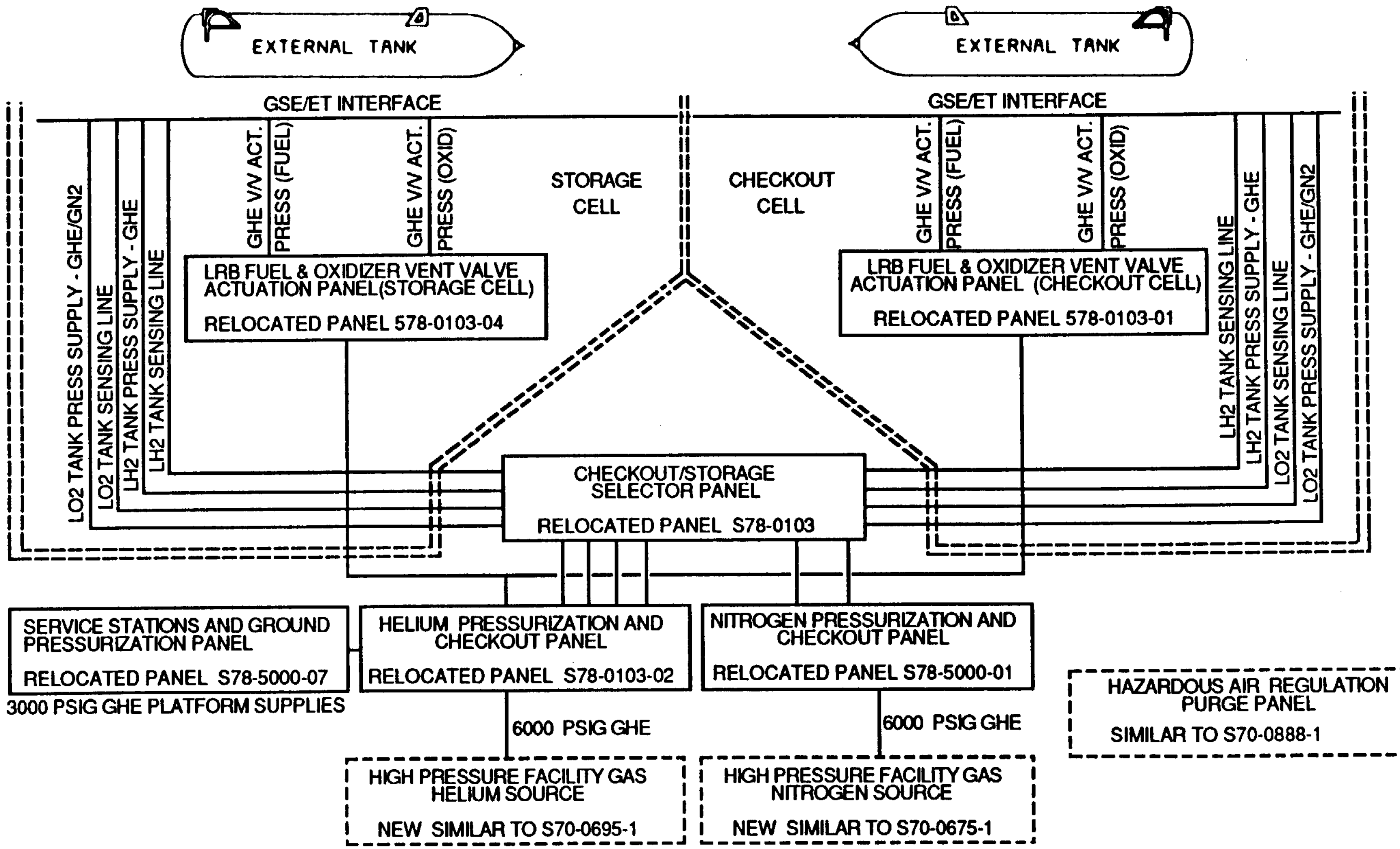


Figure 5.1.1.4. Pneumatic Flow Diagram of GSE for ET Tank Processing.

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Checkout/Storage Selector Panel

The checkout/storage selector panel will select the pressurization and monitoring system for servicing the fuel and oxidizer tanks in either the storage or checkout cell. It is currently located in the VAB (PMN S78-0103) and could be relocated to the new facility.

ET Nitrogen Pressurization and Checkout Panel

This panel will be used to service the ET oxidizer tanks for both storage and checkout cells by regulating facility supply to 3000 psig to deliver a constant GN2 flow rate for maintaining positive pressures during checkout and leak test operations. In addition, the panel will monitor tank pressure and provide, via LPS indication, overpressure protection by remotely controlling the ET oxidizer tank vent valves. The panel is located in the VAB (PMN S78-5000-01) and could be relocated to the new facility.

5.1.1.5 Conclusions/Recommendations

The existing ET Processing ground support system panels in the VAB could be removed and used in the new ET/LRB Processing Facility.

The existing GSE panels used at OPF could be duplicated and/or modified to support the LRB system. If, as assumed, the LRB propulsion system is expendable, the GN2 heater panel and the drag-on purge panel would not be required. These panels would be used only if the propulsion system is to be retrievable.

5.1.2 LRB Engine Horizontal Servicing/Handling

This section presents the facility requirements needed to support the engine-related processing activities of the LRB, which should be confined to the HPF, LRB Integrated Processing Area, and the Launch Pad. The major part of the engine-related work will be conducted in and from the HPF, which will be the nucleus for the engine-related processing operations. This facility should provide for the receipt, storage, installation/removal, modification, checkout, and maintenance of the engines and any related operations associated with the GSE needed for engine processing. For further detail see Volume III, Section 18.

5.1.2.1 Description of Equipment (GSE)

The GSE to support the LRB engine operations has been grouped into three operational categories that include engine handling, checkout/servicing, and facility support.

The engine handling category will include all engine and engine component movement and support. Such activities as shipping/receiving an engine, engine preparation for vehicle installation and removal, and component handling/installation/removal are included in this category.

Engine checkout and servicing will include items such as engine protection, inspection, all mechanical/fluid/electrical checkouts, and servicing and closeout requirements for launch.

Facility support denotes the facilities-type GSE required to ensure the performance of the other categories.

5.1.2.2 New LRB Engine-Servicing/Handling Equipment Concept

For engine handling and servicing/changeout, a new slightly modified version of the following GSE main equipment currently being used by Rocketdyne for the SSMEs should be employed.

Hyster Lift Truck, used to install and/or remove an engine with the SRB in a horizontal position (Figure 5.1.2.2-1).

Rotating Sling, used to rotate the engine to a vertical position from the engine handler (Figure 5.1.2.2-2).

Engine Handler Sling, used to load/unload engine handler (Figure 5.1.2.2-3).

Engine Handler, used to ship, store, and perform minor maintenance while engine is in a horizontal position (figure 5.1.2.2-4)

5.1.2.3 Conclusions/Recommendations

Since the LRB and its propulsion system are in a conceptual stage, specifying the exact GSE configuration needed for support of these systems cannot be done. The conceptual configuration

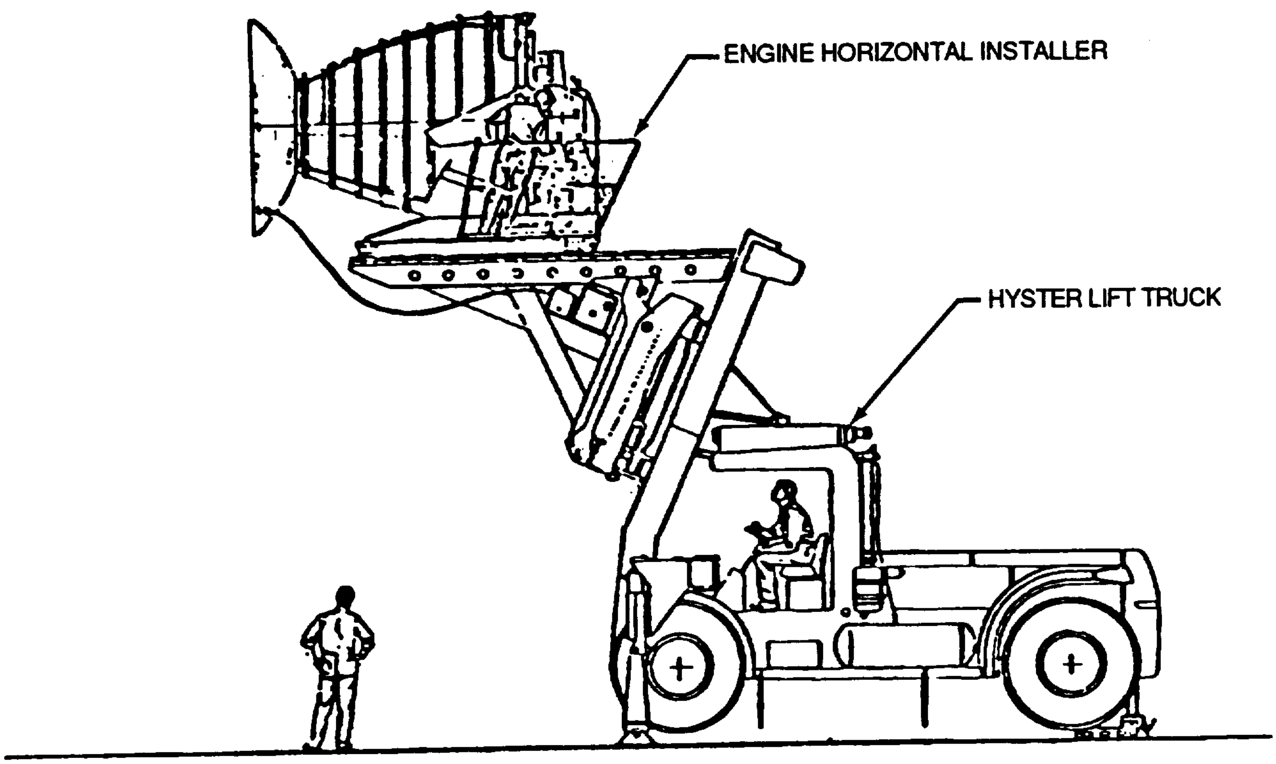
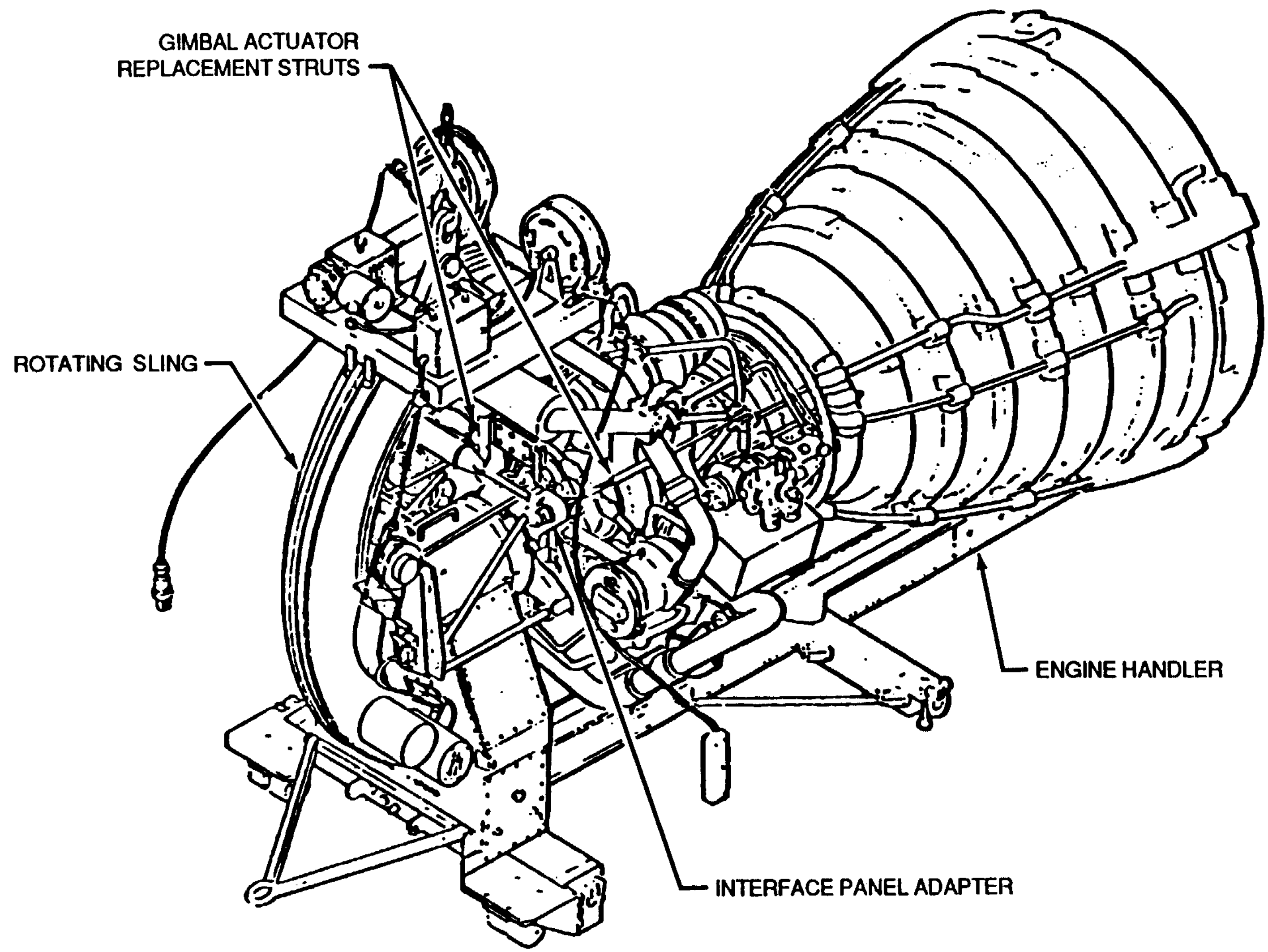


Figure 5.1.2.2-1. LRB Engine Removal / Installation GSE (Hyster).

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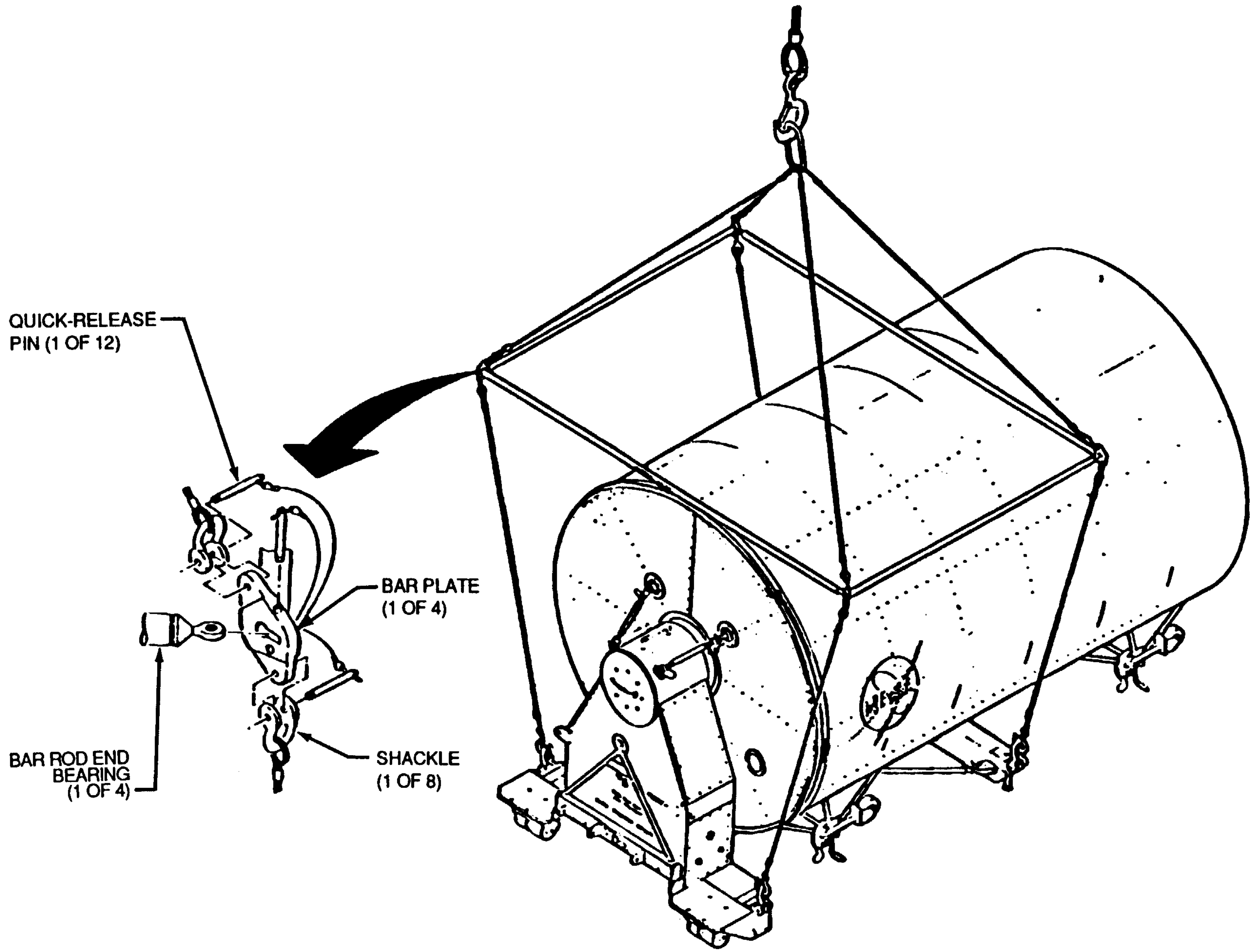
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Figure 5.1.2.2-2. LRB Engine Rotating Sling GSE.

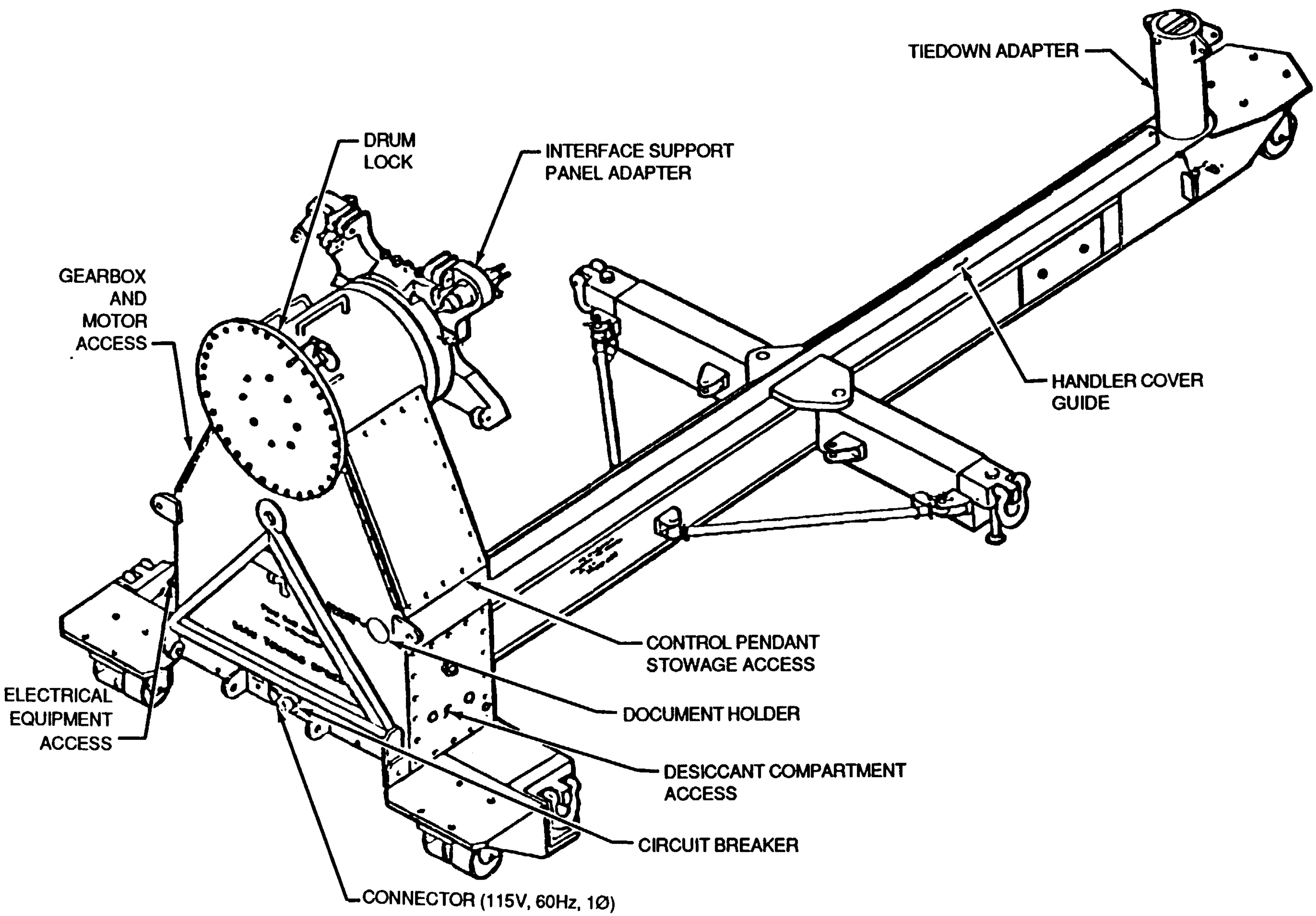
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Figure 5.1.2.2-3. LRB Engine Handler Sling

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Figure 5.1.2.2-4. LRB Engine Handler GSE.

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of the LRB engines and the processing operation, however, can use the same nonintegrated and integrated requirements and equipment as the existing STS.

The conceptual LRB engine processing characteristics are similar to the processing of the SSMEs; therefore, the GSE now used by Rocketdyne for support of the SSMEs should be considered (with appropriate modifications) for use on the LRB engines.

5.1.2.4 Reference Documentation

OMI NO. V5087 REV C	SSME/GSE Handling Operations
OMI NO. V5058 REV H	SSME Removal - Horizontal

5.1.3 ET/LRB Processing Facility Electrical - GSE

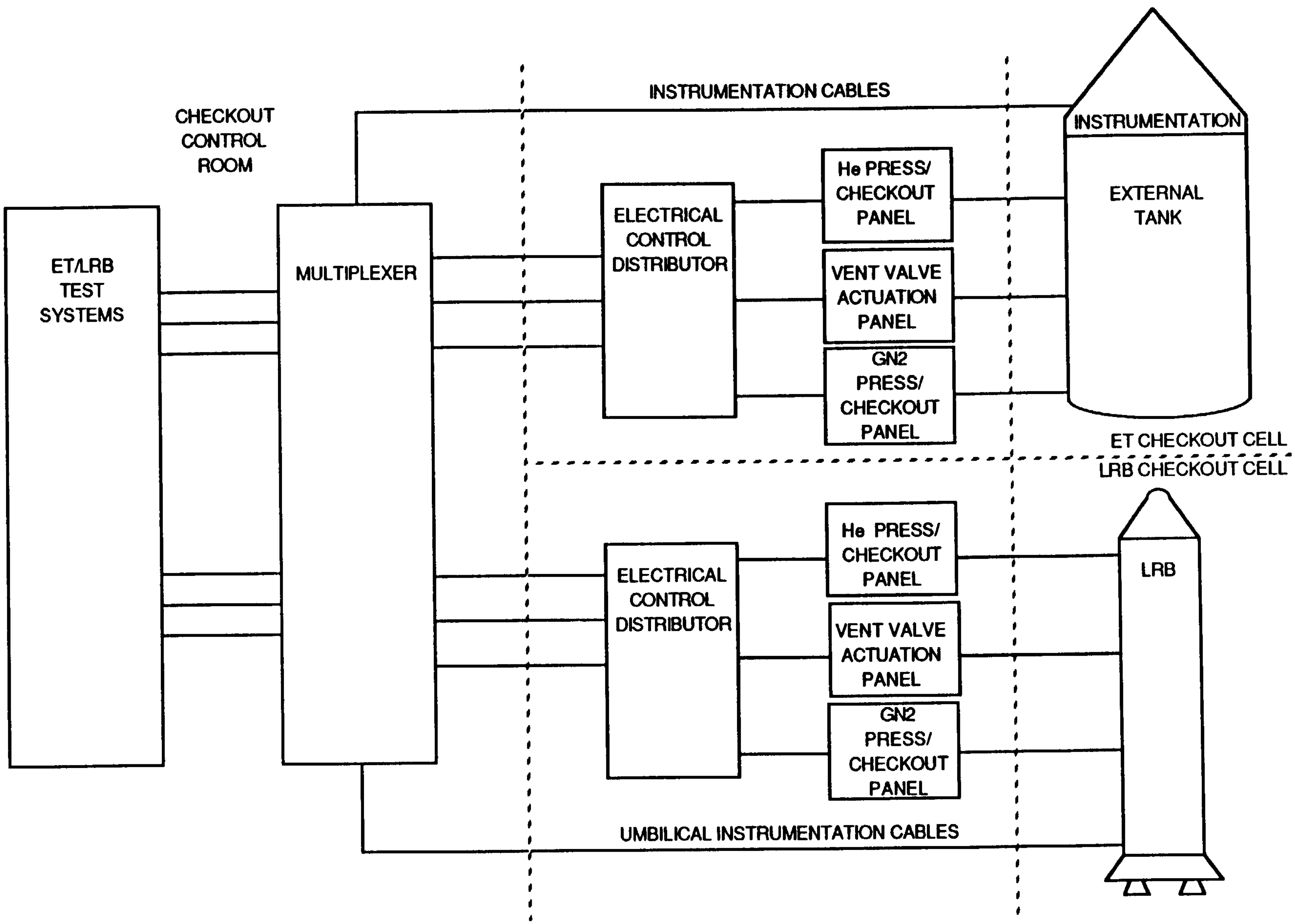
This paragraph provides a concept for electrical equipment requirements to support arrival, component, and systems testing on the LRBs and ETs after arrival to KSC.

5.1.3.1 Requirement

Currently VAB High Bay 4 is being used to test and store External Tanks (ET). For the purposes of LRB testing the VAB High Bay will be converted from ET testing to Shuttle stacking and integrated testing. All existing ET test equipment in this High Bay will have to be moved to the HPF for testing and monitoring ETs.

Electrical systems on the LRBs are more complex than the existing SRBs and warrant special checkout procedures. This will require new equipment (Figure 5.1.3.1) so that testing can be performed in a similar manner to those used in Orbiter systems testing. The LRBs will require a complete system checkout before being moved to a high bay for stacking.

Testing will be performed quickly and will require an absolute minimum of movement of ETs or LRBs through the use of a concept involving multiplexers for soft switching between test cells. This will enable testing to be performed in any test cell on any ET or LRB component.



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Figure 5.1.3.1. ET/LRB Processing Facility - Electrical Controls.

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Test and support equipment will be concentrated, where practical, in centralized and environmentally controlled equipment rooms. Electrical cables will be placed in trenches in the floor, with grating to permit crossover. This will allow for ease of maintenance and more room in the test cells and will permit system growth and expansion of requirements.

Equipment such as cranes that require local operation and monitoring will be operated by using a plug-in modular controls connected to equipment cabinets through cables in the underfloor trenches to the control cabinets. Facility systems such as HVAC, Power, and Firex will be controllable both remotely from the LCC Complex Control Center and locally in the HPF.

5.1.3.2 Conclusions/Recommendations

ET test equipment relocated from the VAB High Bay 4 will pose no major difficulties. It is assumed that the electronics on board will be composed of state- of-the-art computer and communications systems for engine control, guidance, and other systems and components. Sophisticated LRB components will require more rigorous testing than the existing SRBs. LRB interfaces are anticipated to handle communication at transmission rates approaching or exceeding the existing Orbiter's interface rates.

The test and support equipment used to process the LRBs must be commensurate with the LRB equipment to be tested and incorporate equivalent self diagnostics.

5.2 VAB INTEGRATION FACILITY GSE

This section will define the GSE needed for integration of an LRB/SSV.

5.2.1 Fluid GSE Requirements

5.2.1.1 LRB Integration Fluid GSE for High Bay 3 and High Bay 4

The integration processing ground support equipment for the liquid rocket boosters will consist of equipment to support tank monitoring, contingency pressurization, vent valve actuation, and LRB engine leak check operations. The baseline requirements for LRB integration are similar to the ET processing operations performed in High Bay 3 of the VAB. A network of similar pneumatic panels are required in High Bay 4 and the LRB-dedicated MLP.

The pneumatic system will consist of a network of pneumatic panels that will regulate and distribute facility helium and nitrogen gases for pressurization, monitoring, safing, maintenance of tank pressures, vent valve operation, and various leak checks. A block diagram showing a proposed pneumatic system configuration for the integration facility is presented in Figure 5.2.1.1-1 and 5.2.1.1-2.

The existing VAB facility helium and nitrogen high pressure regulation and control system can be used to regulate and distribute the facility gas to the pneumatic support system.

LRB Fuel and Oxidizer Vent Valve Actuation Panel

Maintenance of liquid rocket booster propellant tank pressures during the integration operations requires the constant capability to actuate the propellant tank vent valves to support tank purge and pressurization operations for each LRB. The vent valve actuation panel regulates a 3000-psig helium facility supply to valve actuation pressures. The panel interfaces with each fuel and oxidizer vent valve actuator through the intertank GSE interface. The panel will be LPS controlled or manually operated to support all operations which require tank venting. This panel also could be utilized to provide high flow helium gas to support a contingency pressurization operation.

This equipment is similar to equipment utilized for ET processing in the integration cell High Bay 3. (PMN S72-0680-01)

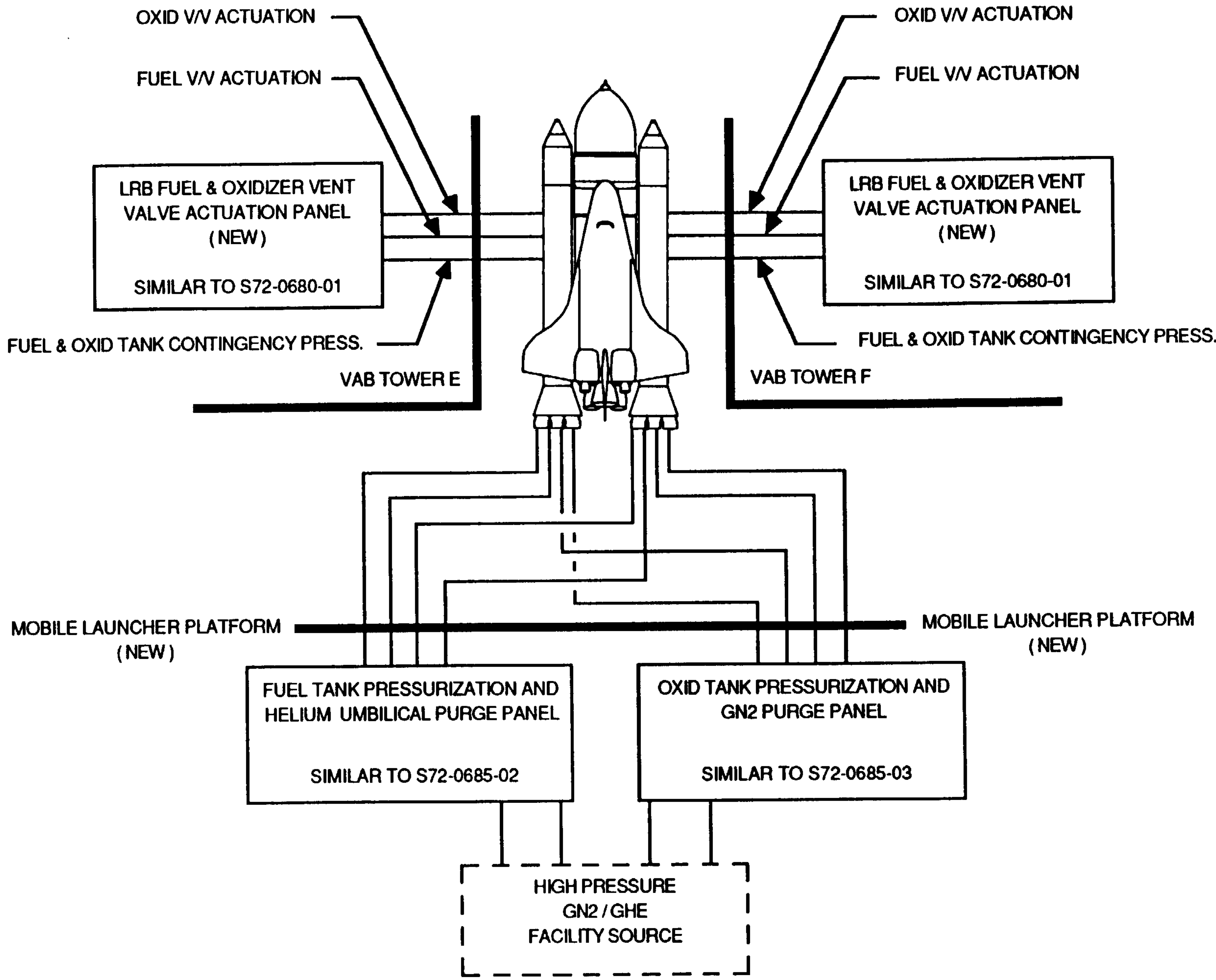
Fuel Tank Pressurization and Purge Panel

LRB propellant tanks and engine purge, pressurization, and monitoring operations are supported by the LRB intransit pressurization equipment within the MLP. The fuel tank pressurization and helium purge panel controls can be remotely or manually operated to regulate facility helium for LRB Fuel tank and engine pressurization and checkout. Fuel tank pressurization and monitoring will be accomplished by connection from the LRB Fuel press line to an interface at the TSM.

This equipment will be new but similar to equipment utilized for ET processing. (PMN S72-0685-02).

LOX Tank Pressurization and Purge Panel

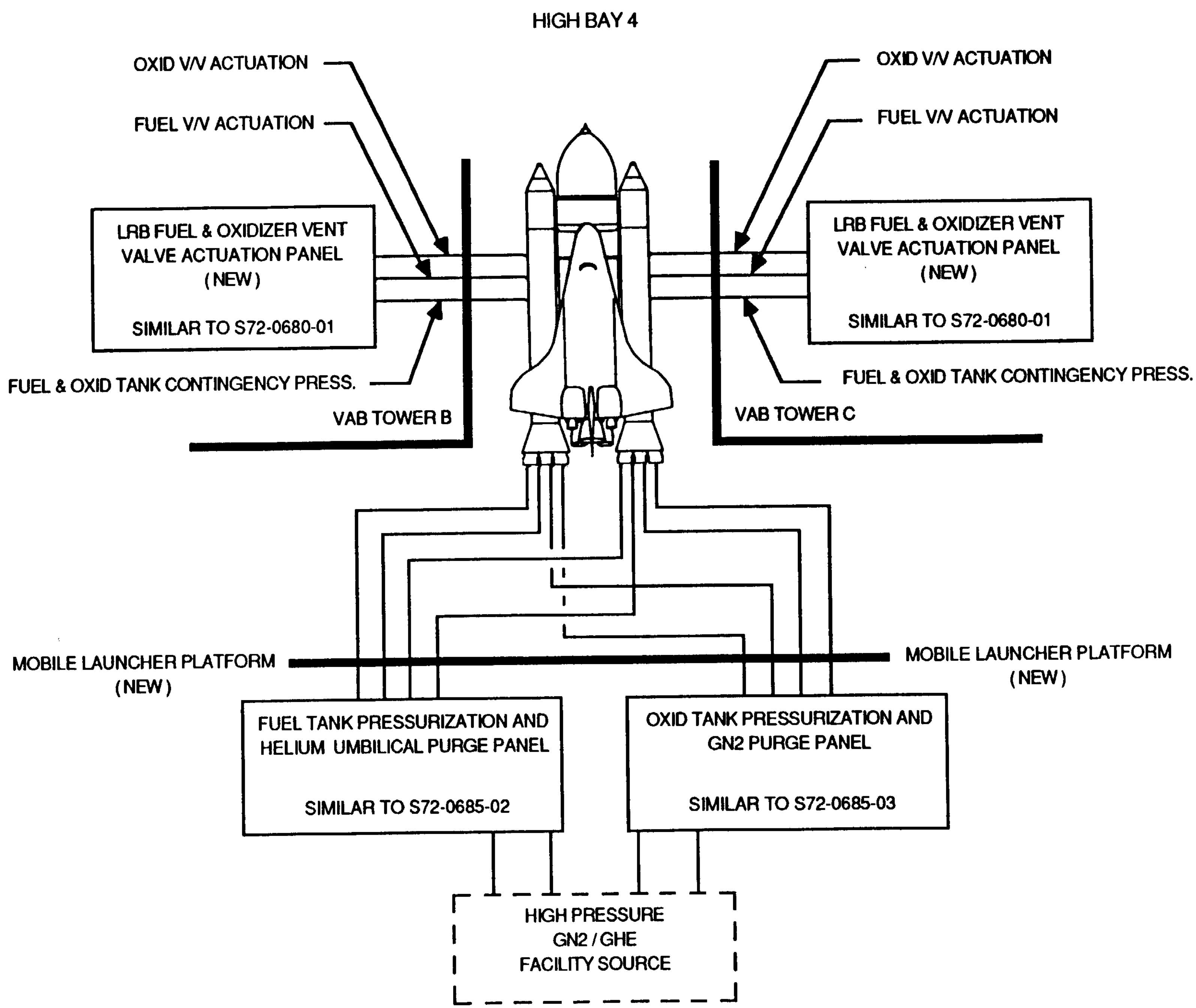
LRB oxidizer and fuel tanks, and engine purge, pressurization and monitoring operations will be supported by the LRB intransit pressurization equipment within the MLP. The LO2 tank pressurization and nitrogen purge panel controls can be remotely or manually operated to regulate facili-



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Figure 5.2.1.1-1 LRB GSE For High Bay 3 Integration Cell.

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Figure 5.2.1.1-2 LRB GSE For High Bay 4 Integration Cell.

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ty helium and nitrogen for LRB LO2 tank and LRB engine purge, pressurization, and checkout. LO2 tank pressurization and monitoring will be accomplished by connection from the LRB LO2 press line to an interface at the TSM.

This equipment will be new but similar to equipment currently being utilized for ET processing. (PMN S72-0685-03).

5.2.1.1.1 Conclusions/Recommendations

Although not specifically addressed in the preceding paragraphs, expansion of the facility helium and nitrogen systems in the VAB will be required. This would be caused by the engine purge requirements and tank volumes of 37,000 cu. ft. (minimum) of the LRB pair.

New panels dedicated to LRB processing will be required in the new MLP and along the towers of the High Bays.

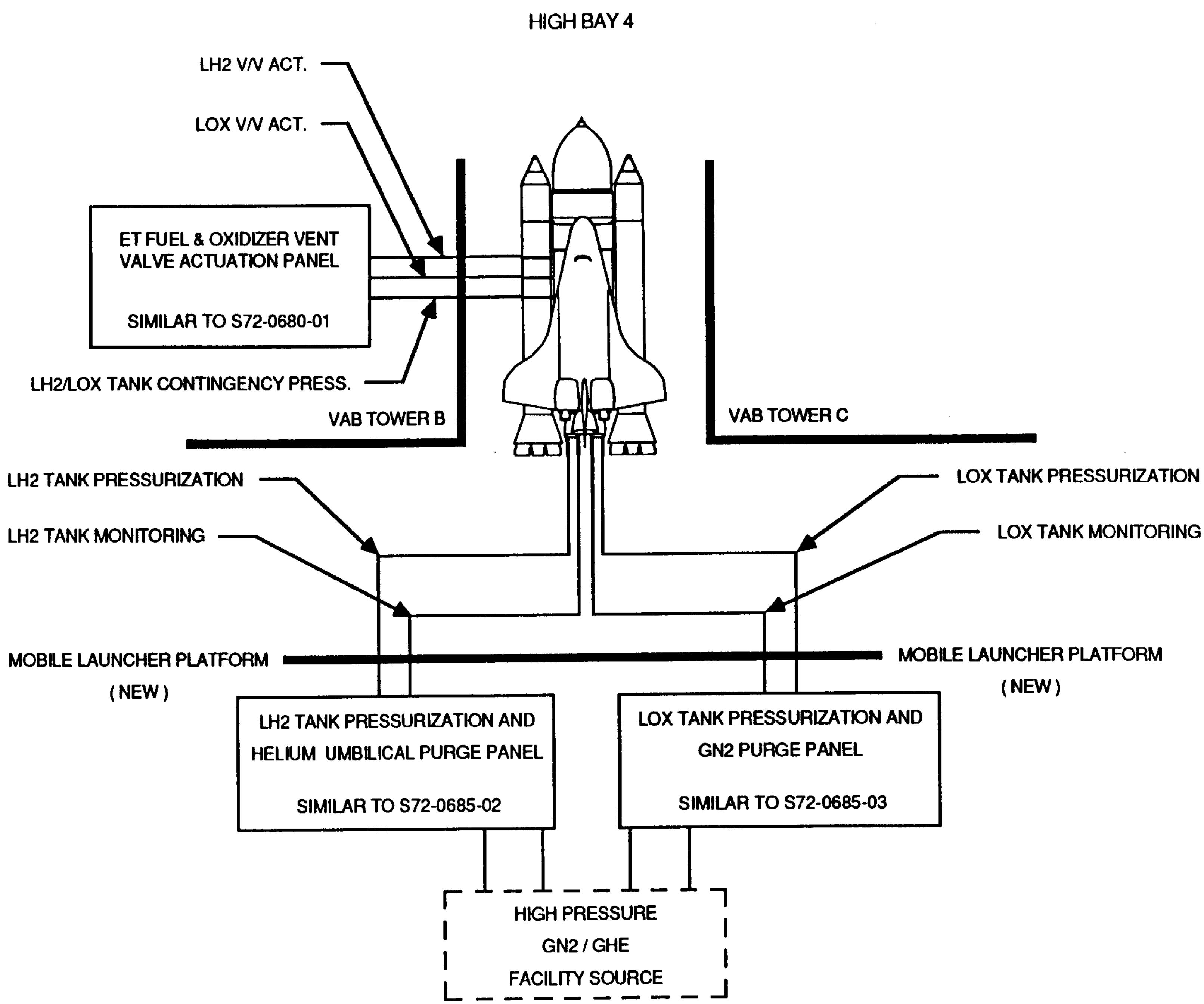
5.2.1.2 Orbiter/ET Integration Fluid GSE for High Bay 4

This Paragraph will define the GSE necessary to process the ET in the integration cell in High Bay 4.

The GSE required for integration of the Orbiter/ET/LRB consists of equipment to support tank monitoring, contingency pressurization, vent valve actuation, and main engine leak check operations. In addition, a pneumatic system similar to those in use in High Bay 3 will be required and would consist of a network of pneumatic panels that regulate and distribute facility helium and nitrogen gases for pressurization, monitoring, safing, maintenance of tank pressures, vent valve operation, and various leak checks. A block diagram showing a proposed system configuration for the integration cell is contained in Figure 5.2.1.2. The components required for Orbiter/ET integration are as follows:

High Pressure Facility Gas Source

The existing VAB facility helium and nitrogen high pressure regulation and control system can be used to regulate and distribute the facility gas to the pneumatic support system.



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Figure 5.2.1.2 Orbiter/ET GSE For High Bay 4 Integration Cell.

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ET Fuel and Oxidizer Vent Valve Actuation Panel

Maintenance of ET tank pressures during the integration operations will require the constant capability to actuate the tank vent valves to support tank purge and pressurization operations. A vent valve actuation panel will regulate a 3,000-psig helium facility supply to valve actuation pressures. The panel will interface with each fuel and oxidizer vent valve actuator through the intertank GSE interface. It will be LPS-controlled or manually operated to support all operations which require tank venting. The panel can also be utilized to provide high flow helium gas to support a contingency pressurization operation. This equipment is identical to that used for ET processing in the High Bay 3 integration cell. (PMN S72-0680-01.)

LH2 Tank Pressurization and Helium Umbilical Purge Panel

The engines, post-ET/Orbiter mate purge, pressurization, and monitoring operations will be supported by the ET intransit pressurization equipment within the MLP. The LH2 tank pressurization and helium umbilical purge panel controls will be remotely or manually operated to regulate facility helium for ET LH2 tank and main engine pressurization and checkout. Pre-Orbiter mate LH2 tank pressurization and monitoring will be accomplished by connection from the ET LH2 press line to an interface at the TSM. This equipment will be new, yet identical to equipment utilized for ET processing. (PMN S72-0685-02).

LOX Tank Pressurization and GN2 Purge Panel

The engines, post ET/Orbiter mate purge, pressurization and monitoring operations will be supported by the ET intransit pressurization equipment within the MLP. The LO2 tank pressurization and nitrogen purge panel controls will be remotely or manually operated to regulate facility helium and nitrogen for ET LO2 tank and main engine purge, pressurization and checkout. Pre-Orbiter mate LO2 tank pressurization and monitoring will be accomplished by connection from the ET LO2 press line to an interface at the TSM. This equipment will be new yet identical to equipment utilized for ET processing. (PMN S72-0685-03).

5.2.1.2.1 Conclusions/Recommendations

The GSE required in the VAB High Bay 4 integration area will be identical to the existing system in High Bay 3 that supports the present day ET pre-Orbiter and post Orbiter mate operations. A new ET tank vent valve actuation panel will be required to provide actuation pressures to both tank vent valves. The MLP system should be the same as the MLP system in High Bay 3, having the capability of pressurizing and monitoring ET tanks during pre-Orbiter and post-Orbiter mate

operations.

5.2.2 Electrical Requirements

5.2.2.1 ET/LRB Integration Electrical GSE for High Bay 4

This paragraph establishes the electrical requirements necessary to allow the performance of integrated Shuttle vehicle testing in VAB High Bay 4. This testing is performed after the LRBs, ET, and the Orbiter are mated in launch configuration and prior to Roll-To-Pad. These tests will include all functions and capabilities currently associated with the operations performed in VAB High Bays 1 and 3.

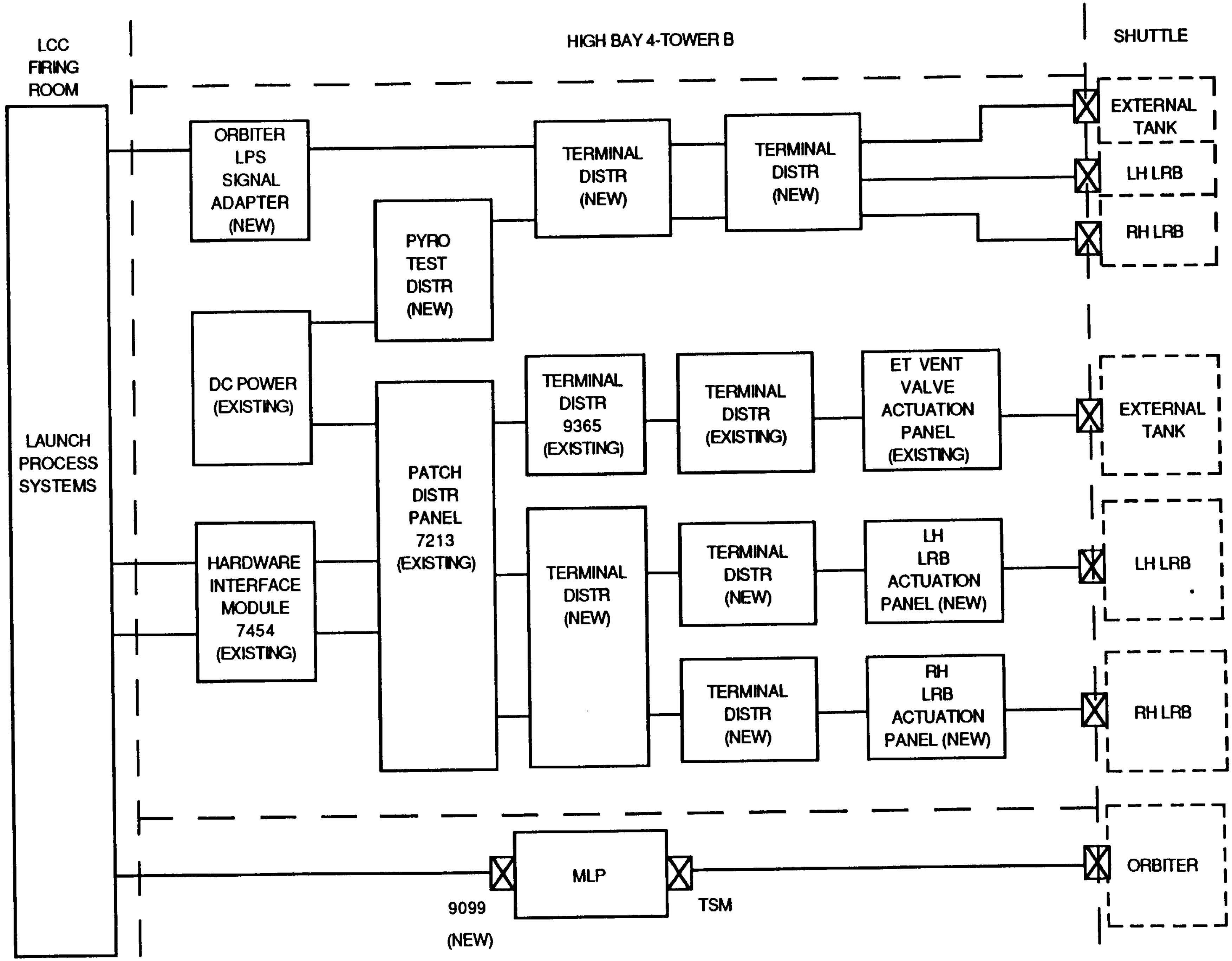
5.2.2.1.1 Requirement

The VAB High Bay 4 will be equipped with LPS controlled electrical hardware and monitoring equipment (Figure 5.2.2.1) to perform Orbiter/ET/LRB integrated system testing, verifications, and validation. Links from the Firing Room LPS to High Bay are necessary to maintain and verify vehicle integrity and perform tests between the major vehicle components. Major functions tested in this configuration will be ET vent valve actuation, LRB vent valve actuation, and pyrotechnic testing.

ET vent valve actuation panels are already available in High Bay 4. New LRB vent valve actuation panels will be located in the Tower adjacent to High Bay 4. Both panels will require interface connections that would provide the same communications that would be required at the Pad. These connections will be made via umbilicals. Pyrotechnic system test equipment will also be located in the tower to interface with the ET and LRB segments.

High Bay 4 will be modified to provide LPS checkout of the SSV from the Firing Room. This will require a new 9099 interface to the MLP that would have the same configuration as High Bays 1 and 3.

When the Shuttle vehicle is at the Pad, the ET vent valve connections are made from the ET to the FSS via umbilicals. The ET has umbilical-like connections to permit testing to be performed in High Bays 1 and 3. Both the ET and the LRB will require similar connections for High Bay 4 operations. All other vehicle checkout functions will be tested through the MLP tail service mast



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Figure 5.2.2.1. VAB High Bay 4 Checkout System.

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and the 9099 interface.

5.2.2.1.2 Conclusions/Recommendations

Implementation of this checkout system can be accomplished without any major problems with the provision that the ETs are processed in the new HPF before modifications begin in High Bay 4.

Existing equipment can be used to provide ET vent valve testing capabilities. Most of the equipment needed for LRB vent valve actuation and pyrotechnic testing in High Bay 4 will be new. All new equipment for the 9099 interface will be required.

As additional studies progress into more detail, these functions may vary. These electrical modifications should have no major impact on SRB processing in High Bay 4.

5.2.2.2 ET/LRB Integration Electrical GSE in High Bay 3

This paragraph establishes the electrical requirements necessary to perform integrated Shuttle vehicle testing using LRBs and SRBs in VAB High Bay 3. This testing is performed after the LRBs, ET, and Orbiter are mated in launch configuration and prior to roll-to-Pad. These tests will include all functions and capabilities currently associated with the operations performed in VAB High Bays 1 and 3.

5.2.2.2.1 Requirements

The VAB High Bay 3 will be equipped with LPS-controlled electrical hardware and monitoring equipment (Figure 5.2.2.2) to perform Orbiter/ET/LRB integrated system testing, verifications, and validation. Links from the Firing Room LPS to the High Bay are necessary to maintain and verify vehicle integrity and perform tests between the LRBs and other major vehicle components. Major functions tested in this configuration will be ET vent valve actuation, LRB vent valve actuation, and pyrotechnic testing.

ET vent valve actuation panels are already available in High Bay 3. New LRB vent valve actuation panels will be located in the Tower adjacent to High Bay 3. Both panels will require interface connections that would provide the same communications that would be required at the Pad. These connections would be made via umbilicals. Pyrotechnic system test equipment will also be

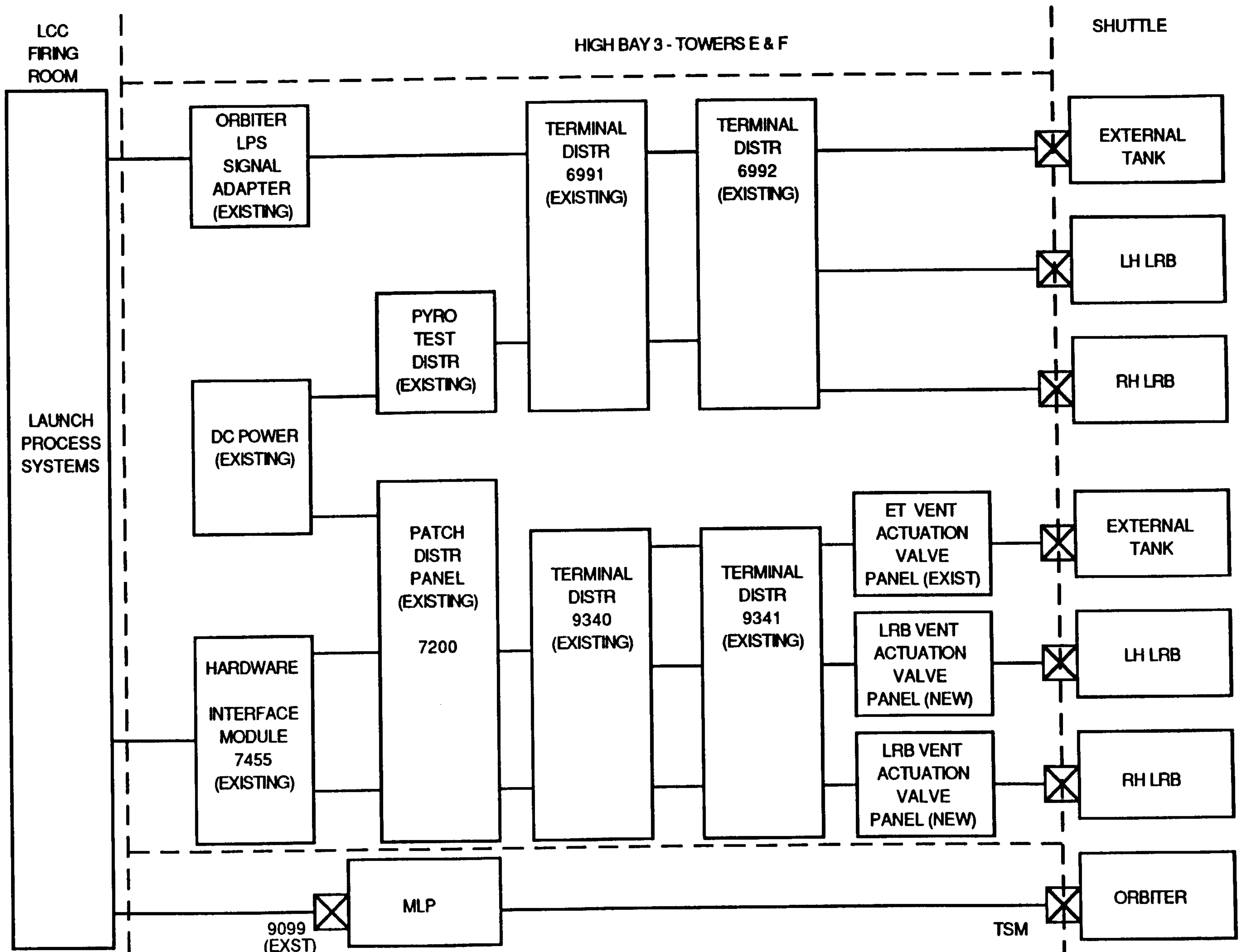


Figure 5.2.2.2. VAB High Bay 3 Shuttle Checkout System.

located in the tower to interface with the ET and LRB segments.

High Bay 3 will be modified to provide LPS checkout from the Firing Room to the Shuttle vehicle for the LRBs. This will require a new 9099 interface to the MLP that would have the same configuration as High Bays 1 and 3.

When the Shuttle vehicle is at the Pad the ET vent valve connections are made from the ET to the FSS via umbilicals. The ET has umbilical-like connections to permit testing to be performed in High Bays 1 and 3. Both the ET and the LRB will require similar connections. All other vehicle checkout functions will be tested through the MLP tail service mast and the 9099 interface.

5.2.2.2.2 Conclusions/Recommendations

Implementation of this checkout system can be accomplished without any major problems with the provision that the ETs are processed in the new HPF before modifications begin in High Bay 3.

Existing equipment can be used to provide ET vent valve testing capabilities. Most of the equipment needed for LRB vent valve actuation and pyrotechnic testing in High Bay 3 will be new. Some new equipment for the 9099 interface will be required.

The electrical modifications should have only a minor impact on SRB processing in High Bay 3 due to scheduling.

5.3 MOBILE LAUNCHER PLATFORM GSE

This section will define the GSE needed for the MLP.

5.3.1 Fluid GSE Requirement

The MLP Propulsion Fluid Systems function, in conjunction with the Pad systems, Paragraph 5.4.2 will define the GSE that supports the propulsion systems.

5.3.1.1 Water Ethylene Glycol GSE

RP-1/LOX engines require servicing with water-ethylene-glycol to provide for soft ignition.

Water-ethylene-glycol is also used to pickle the engine lines to reduce electrolysis and contamination and to fill the engine coolant lines. A conceptual system description follows.

During the Apollo program, approximately 1000-plus gallons of water-ethylene-glycol were used to service the five F-1 Saturn engines. It is estimated that the eight LRB engines will require approximately 1600 gallons.

The proposed system will be installed in the MLP so that servicing can be accomplished either at the VAB or the PAD. The system is illustrated in Figure 5.3.1.1. The system will consist of a tanker interface on the side of the MLP that will be used to fill a 3000-gallon storage vessel. Two service panels will be provided to control the commodity flow for each LRB. An interface plate on the MLP "O" deck close to the engine service platforms will be used to connect the GSE with the engine interfaces via flex hoses. Commodity transfer is proposed to be GN2 pressurization of the storage vessel instead of pump. A return line and waste tank will also be required to collect water-ethylene-glycol residuals.

5.3.1.2 Trichloroethylene

During the Apollo program, F-1 engine passivation of the LOX system was performed in the VAB and Pad with trichloroethylene. Since trichloroethylene is a hazardous commodity, passivation will be accomplished with portable GSE. This study has assumed the engine/LRB contractor will perform this passivation.

5.3.2 LRB Engine Vertical Servicing/Changeout

This section defines GSE that will be required to support the engine- related processing activities of the LRB. This processing will take place in the VAB or on the launch pad while the LRBs are in a vertical position. This task will provide for the installation/removal of the LRB engines and the GSE needed to accomplish this. Engine modification, checkout, and maintenance-related operations will be done in the HPF. (For detail see Volume III, Section 18.)

5.3.2.1 Description of GSE

GSE will be needed to support the LRB engine installation/removal; engine checkout and servicing, such as engine protection; inspection; all mechanical/fluid/electrical checkouts; and servicing

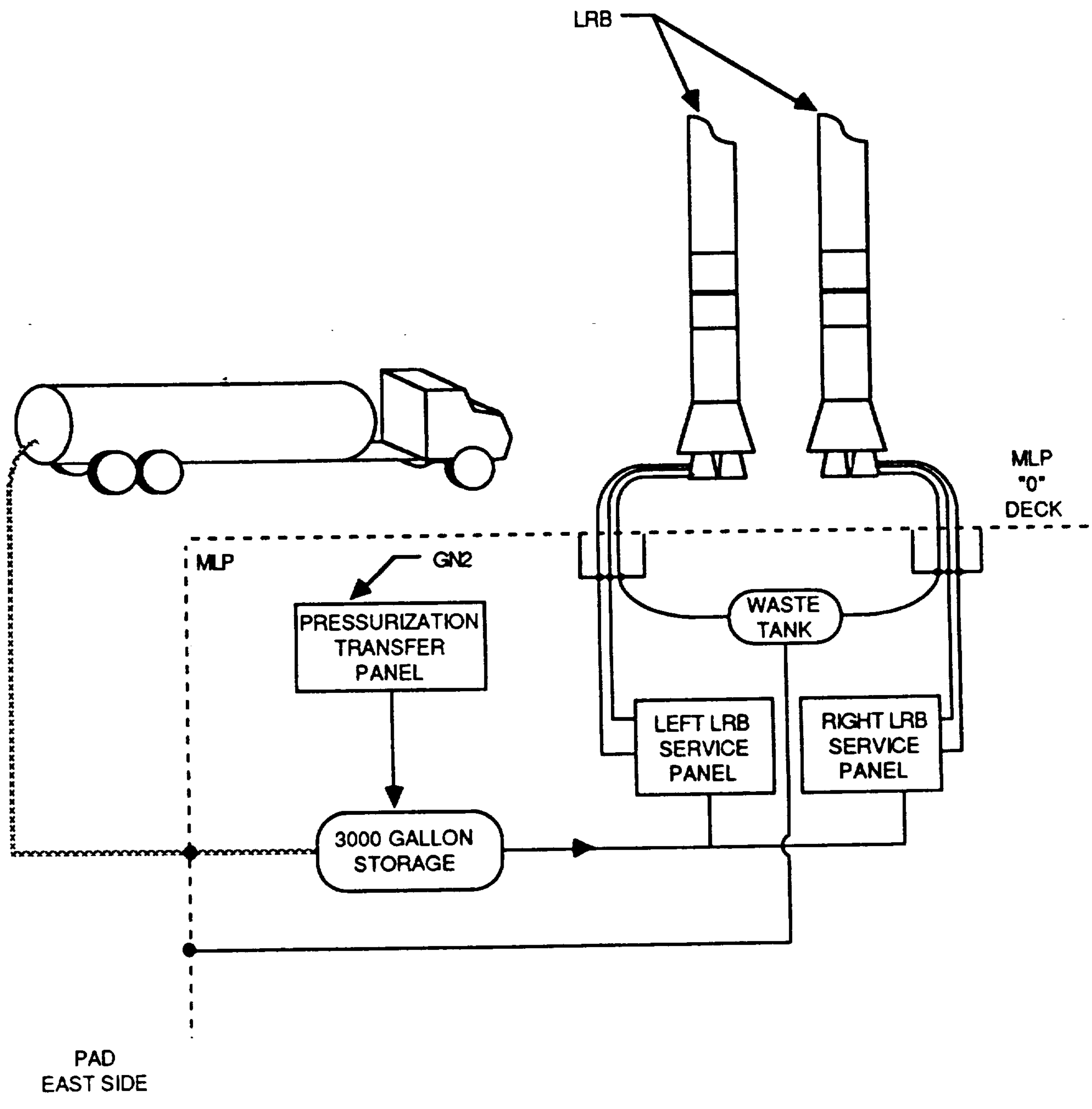


Figure 5.3.1.1. Water-Ethylene-Glycol System.

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and closeout requirements for launch.

5.3.2.2 New LRB Engine-Servicing/Handling Equipment Concept

For engine handling and servicing/changeout, a new, slightly modified version of the following GSE currently being used by Rocketdyne for the SSMEs should be employed:

Engine Vertical Installer, used to install and/or remove an engine with the vehicle in the vertical position (Figure 5.3.2.2-1).

Engine Rotating Sling, used to rotate the engine to the vertical position from the engine handler (Figure 5.3.2.2-2).

Engine Handler, used to ship and store engines; For use when minor maintenance is required and engine is in a horizontal configuration (Figure 5.3.2.2-3).

5.3.2.3 Conclusions/Recommendations

Since the LRB and its propulsion system are in a conceptual stage, specifying the GSE configuration needed for support of these systems cannot be done. The conceptual configuration of the LRB engines and the processing operation, however, can use the same nonintegrated and integrated requirements and equipment as the existing STS. The conceptual LRB engine processing characteristics are similar to the processing of the SSMEs, therefore, the GSE now used by Rocketdyne for support of the SSMEs should be considered (with appropriate modifications) for use on the LRB engines.

5.3.2.4 Reference Documentation

OMI NO. V05087 REV C	SSME/GSE Handling Operations
OMI NO. V05062 REV G	SSME Installation - Vertical
OMI NO. V05063 REV F	SSME Removal - Vertical

5.3.3 LRB Electrical GSE Requirement for MLP

This section will establish the electrical requirements necessary to perform integrated LRB testing

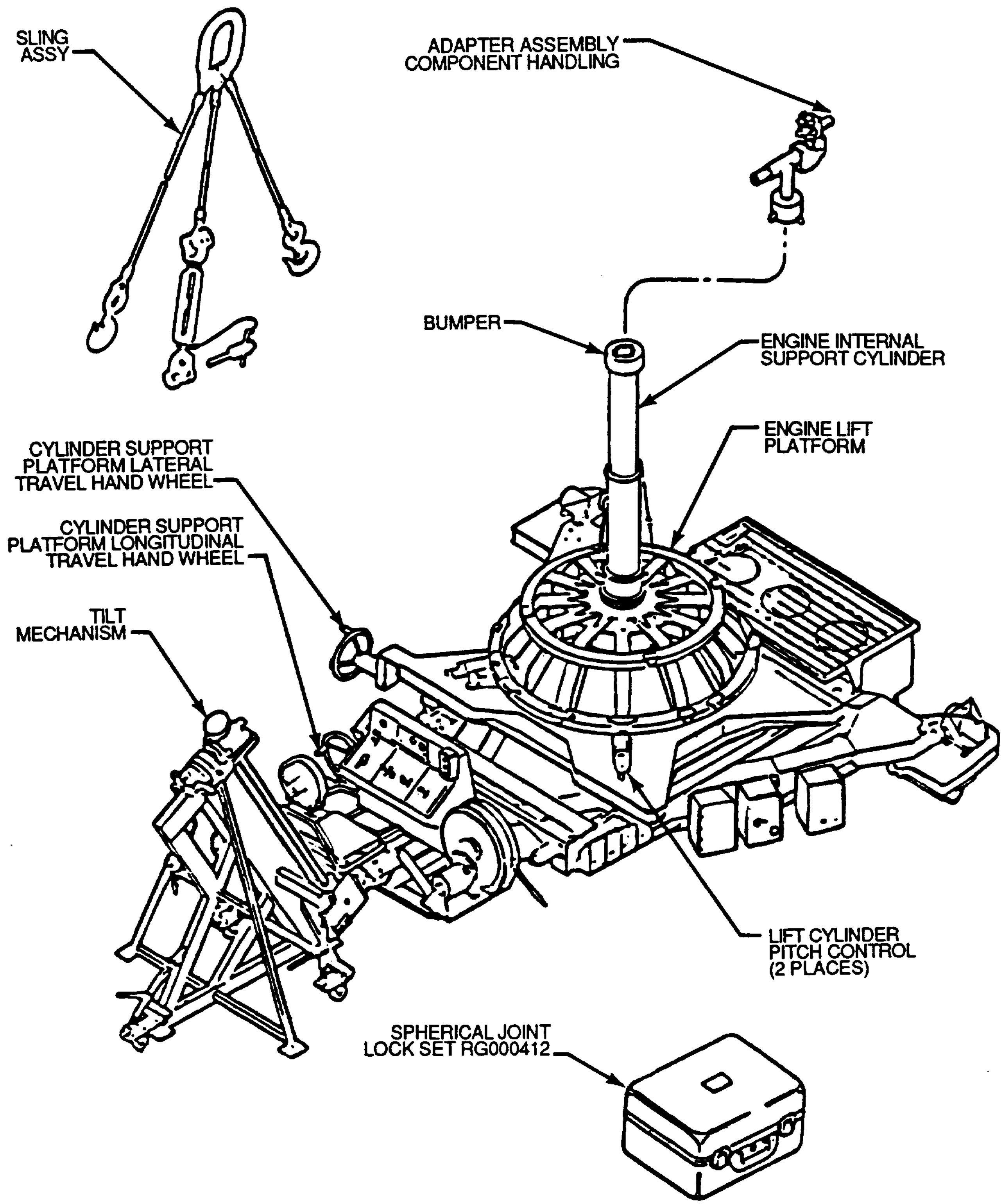
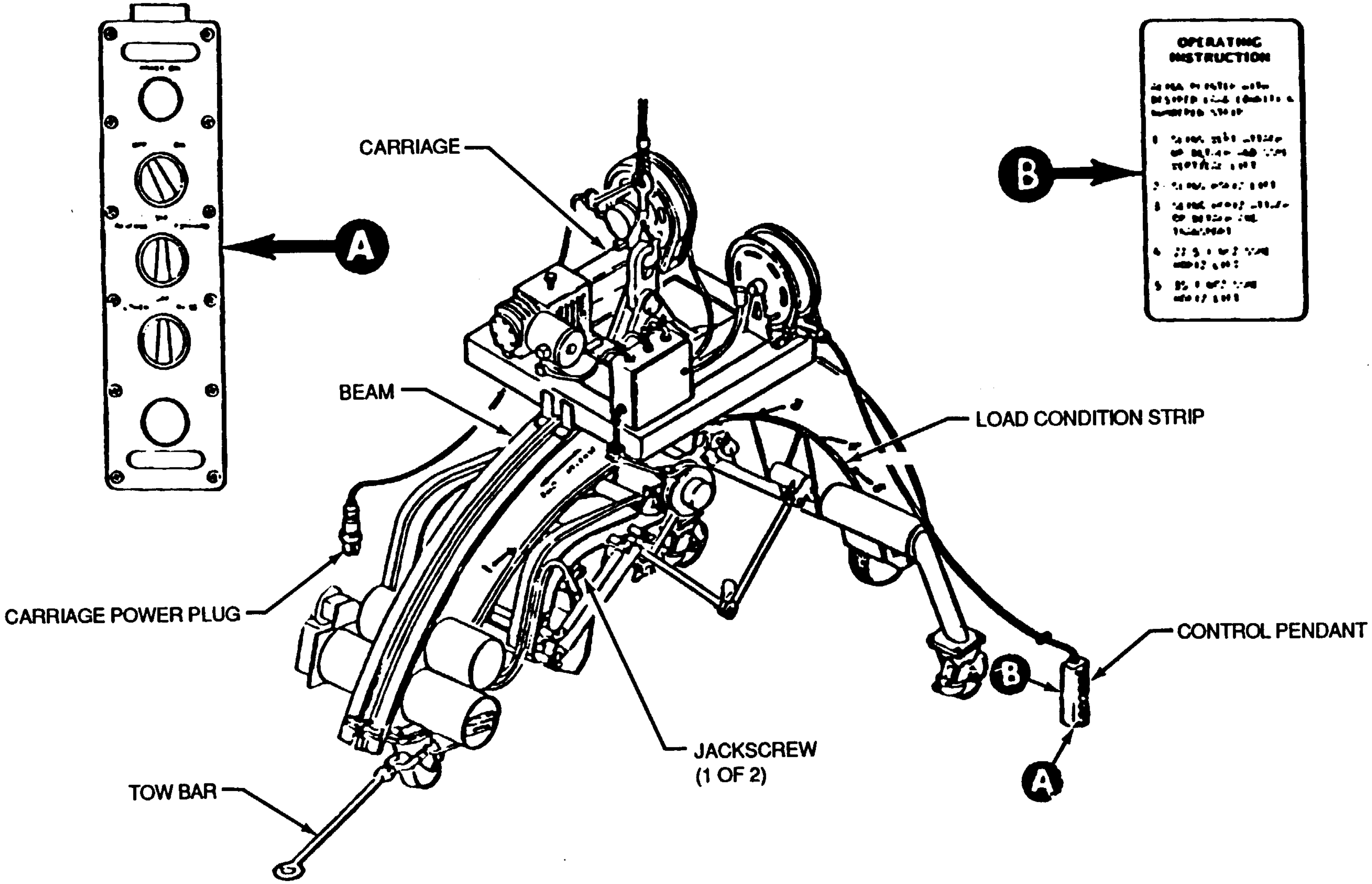


Figure 5.3.2.2-1. Engine Vertical Installer Set

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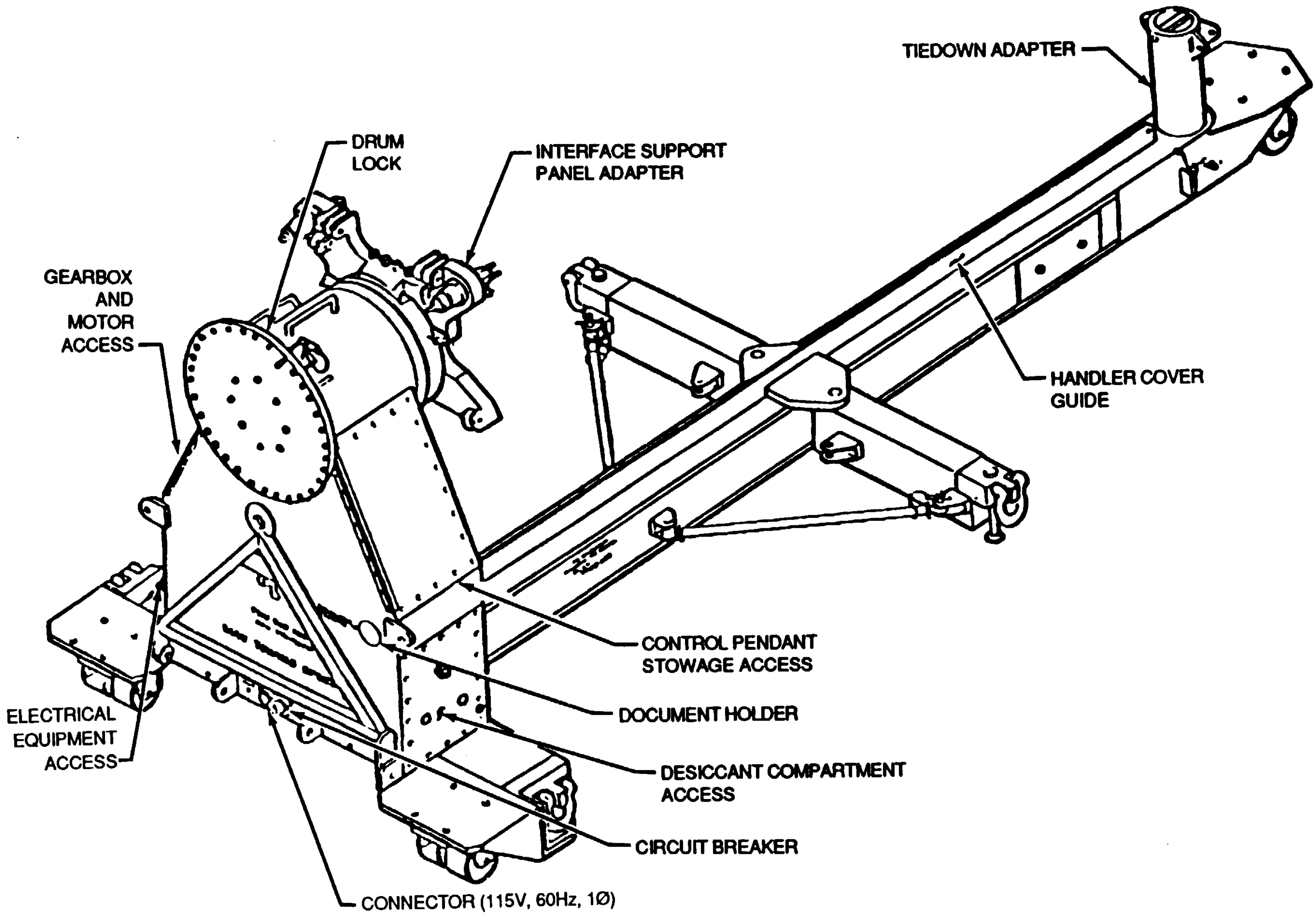


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Figure 5.3.2.2-2. LRB Engine Rotating Sling GSE - Vertical Position.

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Figure 5.3.2.2-3. Engine Handler GSE - Vertical Position.

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on the MLP. Testing in the VAB is performed after the LRBs, ET, and Orbiter are mated and the Shuttle is in launch configuration prior to roll-to-Pad. Testing and launch preparations are performed after the MLP has rolled-to-Pad. The requirements include all functions and capabilities associated with the addition of LRBs to the launch configuration.

5.3.3.1 Requirements

The MLP will be equipped with LPS-controlled electrical hardwire and monitoring equipment to perform LRB integrated system checking, verification and validation. Links for the firing room LPS to VAB and Pad are necessary to maintain and verify LRB integrity and operation.

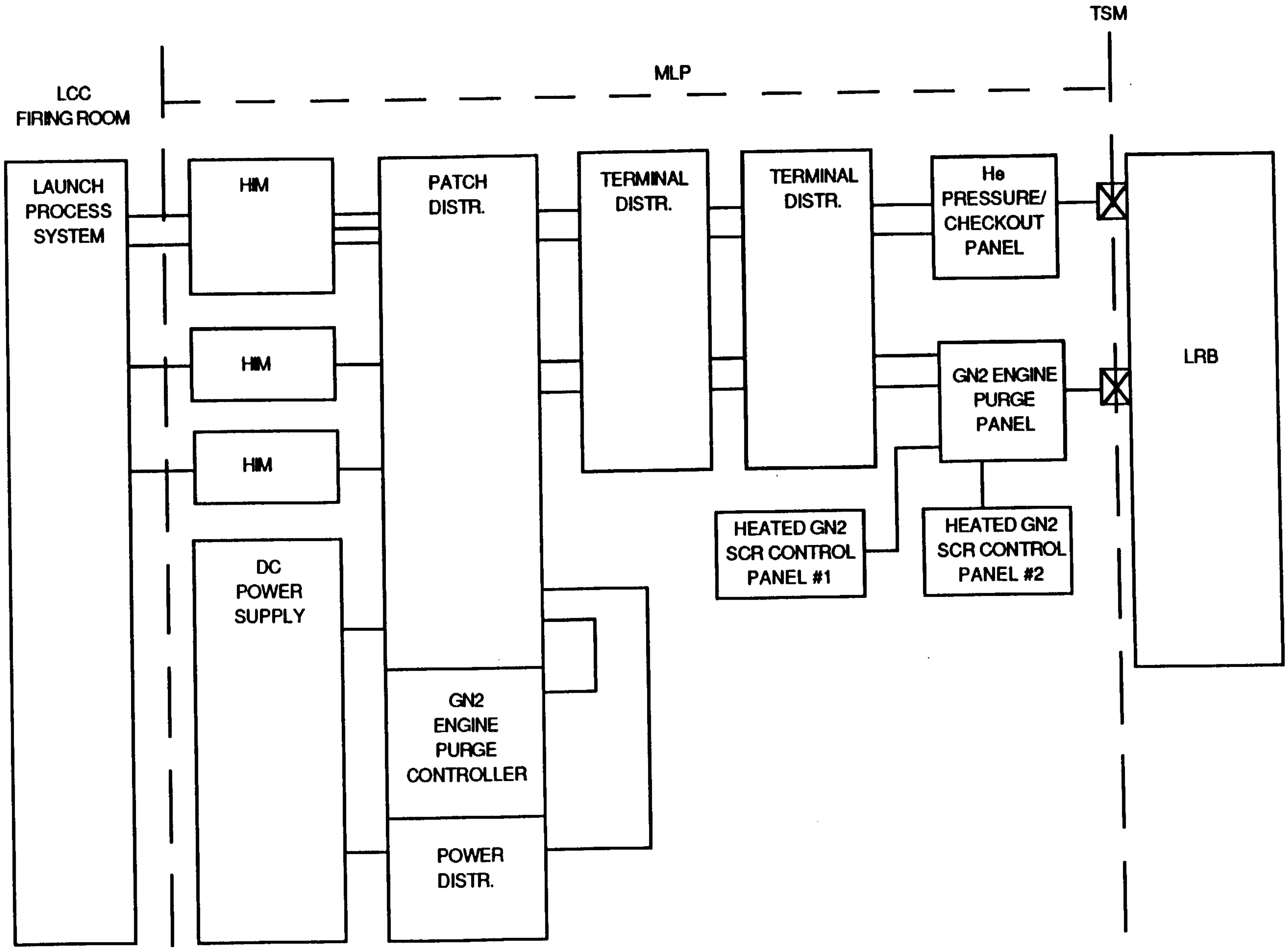
Major functions tested and systems operated in this configuration will be Pyro-Initiator Controller (PIC), LRB engines, propellant systems, DC Power, Permanent Measuring System (PMS), GN2 Pressurization/ Checkout, Helium Pressurization/Checkout, and Development Flight Instrumentation (DFI).

The PIC system is an LPS-controlled ordnance firing signal. This signal activates ground support equipment pyrotechnics causing the orbiter/LRB hold-down bolts to disintegrate, releasing the vehicle for liftoff. This is an existing system and only requires minor changes.

The new LRB main engine checkout system will be an LPS-controlled MLP GSE facility. This facility will have a heated nitrogen supply and control panel for RP-1/LO2 main engine purge, checkout and maintenance. An additional helium purge and checkout panel will be required for the a RP-1/LO2 engine. This system will be similar to the SSME system presently being used (see Figure 5.3.3.1-1). Some existing equipment may be used.

The new fuel tanking system for LRBs, whether it is RP-1, LH2, or LCH4, will be an LPS controlled valve array skid located on the side of the MLP. The fuel system will be similar to the existing LH2 fuel system (see Figure 5.3.3.1-2). An RP-1 system would be much simpler in design than an LH2 or LCH4 system and would only require a basic hazardous warning system (see Figure 5.3.3.1-3). Hardware interface modules for the fuel could be shared with the LO2 system.

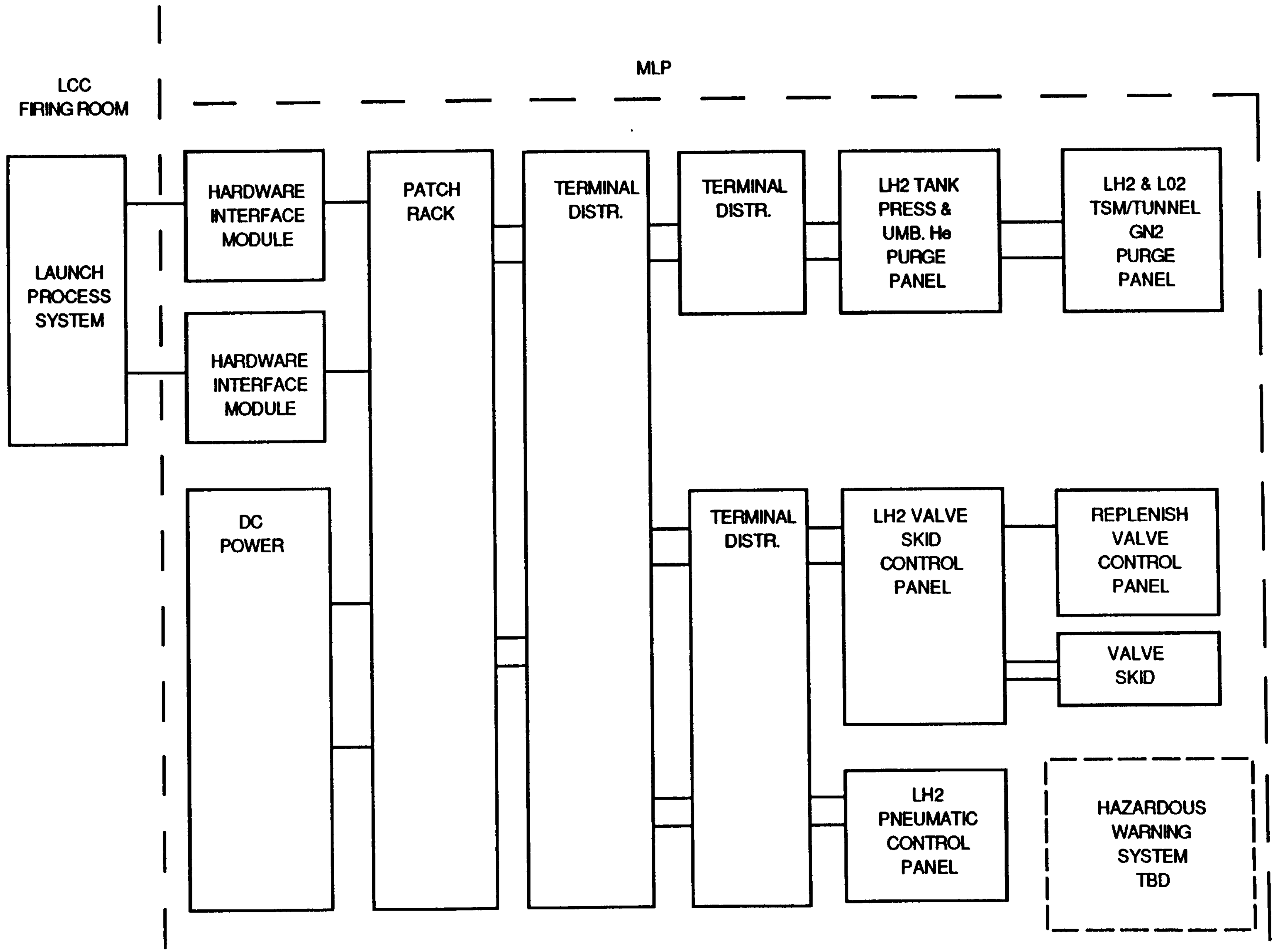
The new LO2 tanking system will be an LPS-controlled valve array skid located on the side of the MLP. This system will also include an LO2 tank pressure and GN2 purge panel, valve control panel, LO2 pneumatic distributor and would have a helium anti-ice panel (see Figure 5.3.3-4).



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Figure 5.3.3.1-1. LRB Engine Checkout Systems - Electrical Controls.

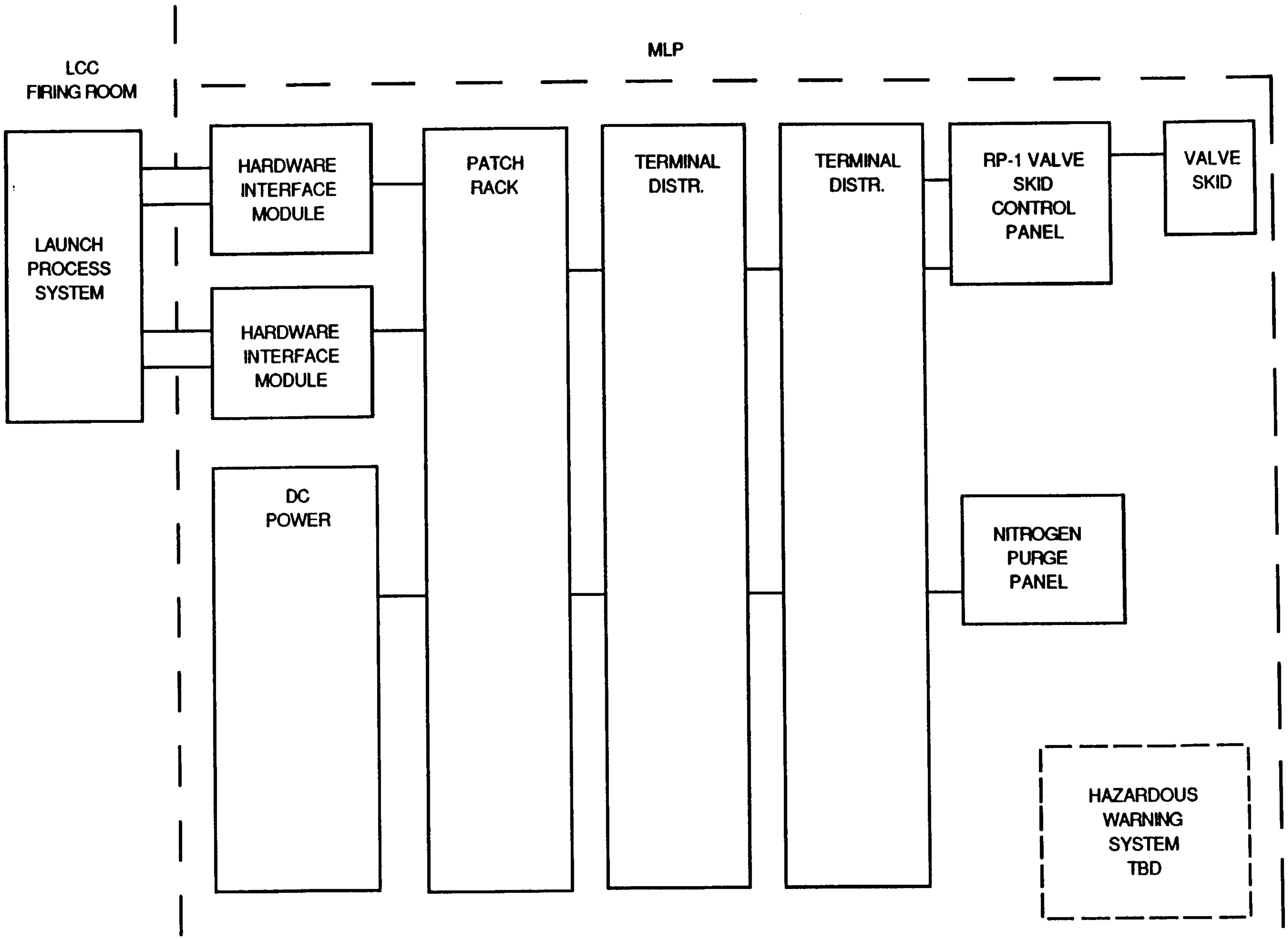
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Figure 5.3.3.1-2. LRB LH2 or CH4 Propulsion GSE System Electrical Controls.

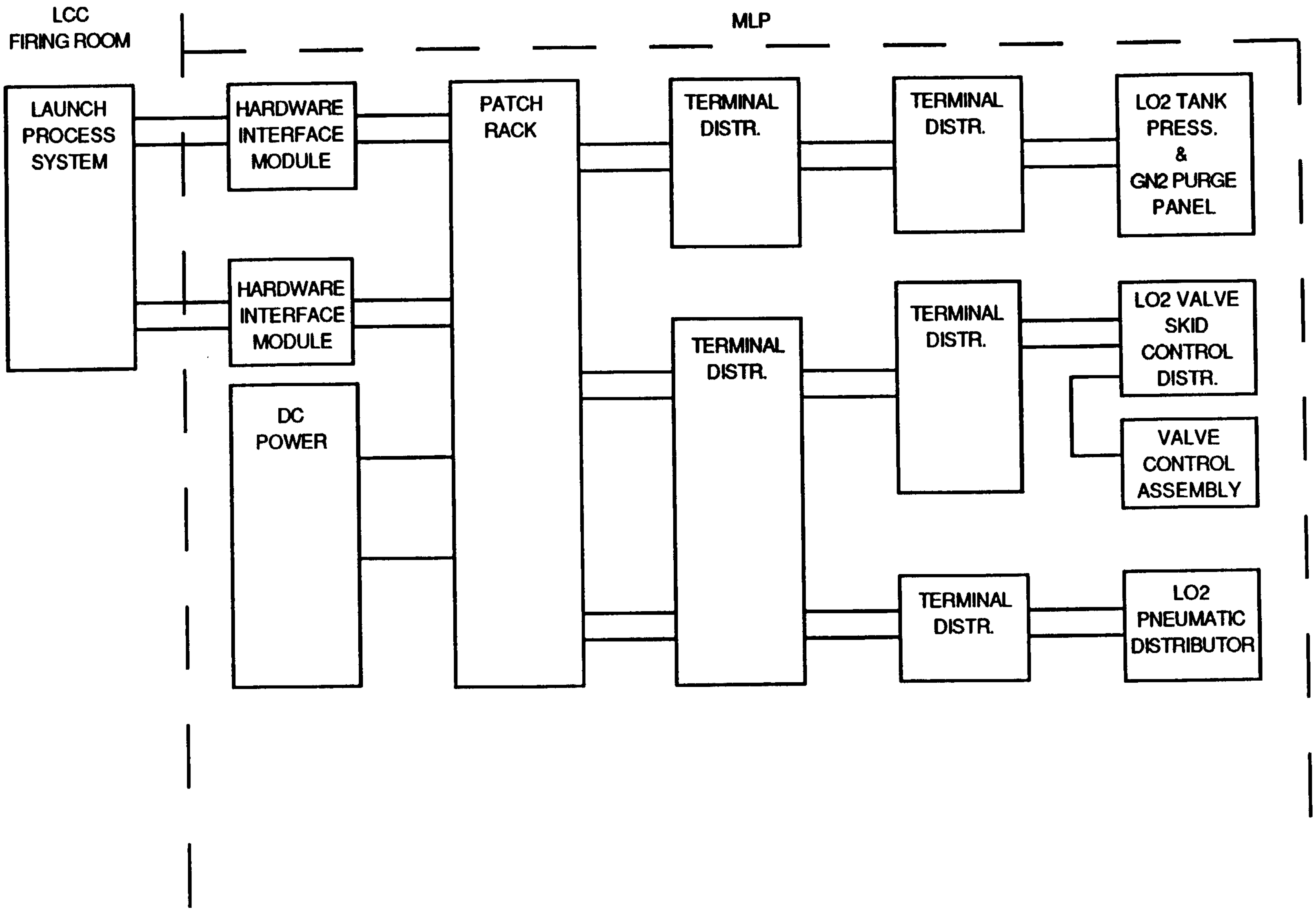
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Figure 5.3.3.1-3. LRB RP-1 Propulsion GSE System Electrical Controls.

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Figure 5.3.3.1-4. LRB LO2 Propulsion GSE System Electrical Controls.

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Hardware interface modules could be shared with the LRB fuel system.
The existing MLP dc power system design will require modifications to support power demands from new systems.

The existing MLP Permanent Measuring System (PMS) design is a remote controlled data collection system in the LCC. This is not an LPS-controlled system. PMS provides for the application of transducers on such types as pressure, vibration, acoustic, temperature, strain, load cells, heat, etc. Modifications to this system design will be performed as the various measurement requirements are identified.

New GN2/He pressure/checkout panels will be required to provide check-out and maintenance requirements for the LRBs. These panels will be LPS controlled (see Figure 5.3.3.1-5).

The existing MLP SRB Development Flight Instrumentation System (DFI) design is an LPS controlled system. The DFI system is a checkout of onboard flight parameters. The extent of DFI requirement will not be known until LRBs reach full design status. DFI has, however, been applied to previous vehicle components. Modifications to support DFI are normally minimal. There is no DFI system currently on MLP-3. If DFI is required to support LRBs, the MLPs could be adapted to support.

5.3.3.2 Conclusions/Recommendations

Implementation of these checkout/operations systems can be accomplished without any major problems.

As additional studies progress into more detail, these MLP functions may vary and other system design requirements may surface.

5.4 LAUNCH COMPLEX 39A AND 39B GSE

This section will define the GSE needed for the Launch Complexes.

5.4.1 Pressure-Fed LRB Pressurization GSE

This section will determine the LRB pressurization requirements and define the ground support

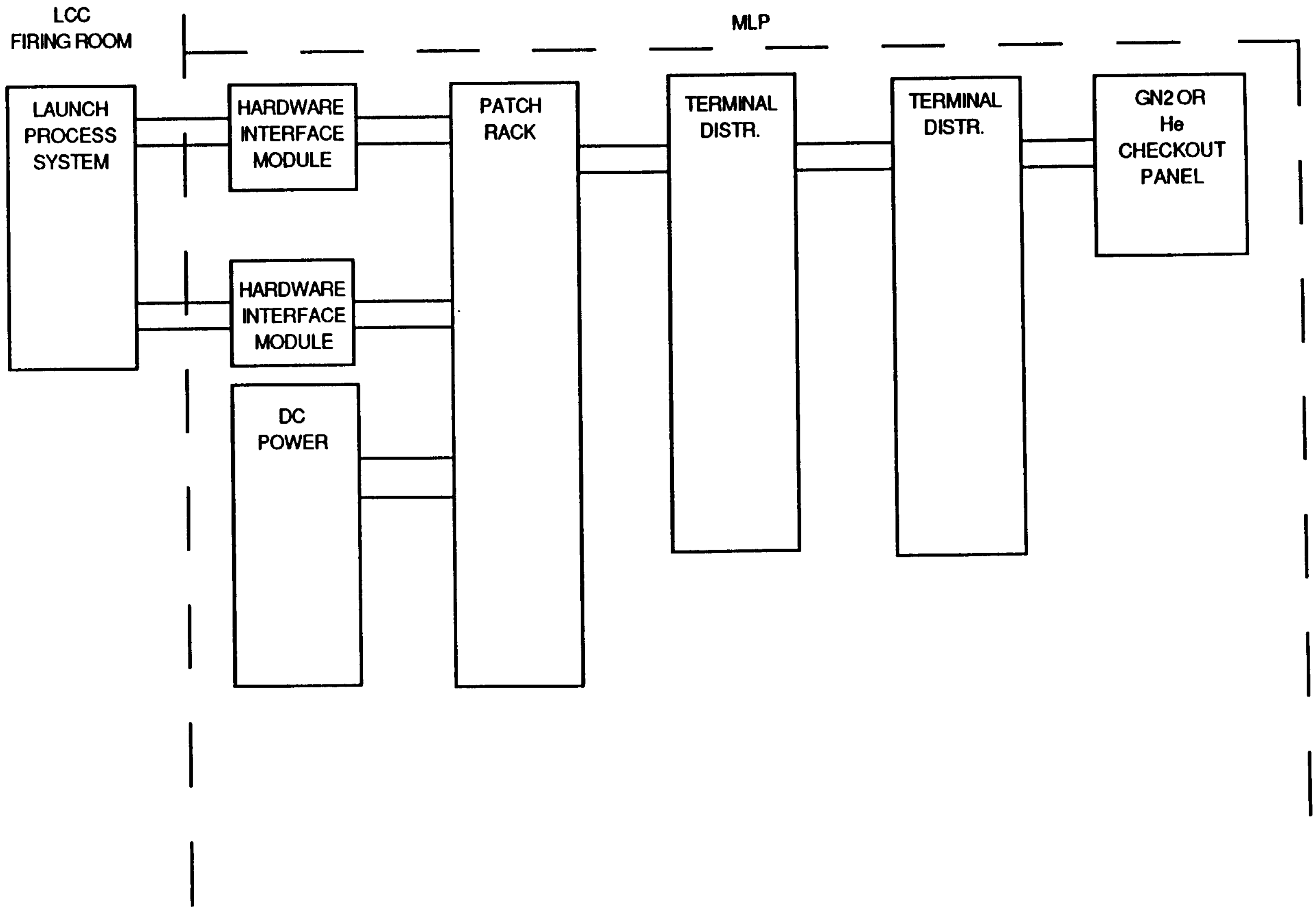


Figure 5.3.3.1-5. Typical Electrical Controls For New GN2/He Pressure/Checkout Panels.

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equipment (GSE) for pressure-fed LRBs.

5.4.1.1 LRB Requirements

The LRB pressure-fed system will be equipped with an onboard pressurant bottle that will be filled pre-launch with pressurant gas to approximately 3,000 psig for delivery of propellants to the LRB propulsion system.

There are two possible pressurant gas candidates being proposed for LRB use:

The General Dynamics configurations use Tridyne (He, H2, O2.) Tridyne will be supplied in tubebank trailers by General Dynamics. The trailers will be parked inside the Pad high pressure gas storage facility. Supply gas from the tubebank will be conveyed via flex hoses and tubings routed in the Pad trench, the high pressure gas tower, in the MLP tunnel, and finally in the pressurant regulation panel where it will be regulated, monitored, and delivered to the LRBs.

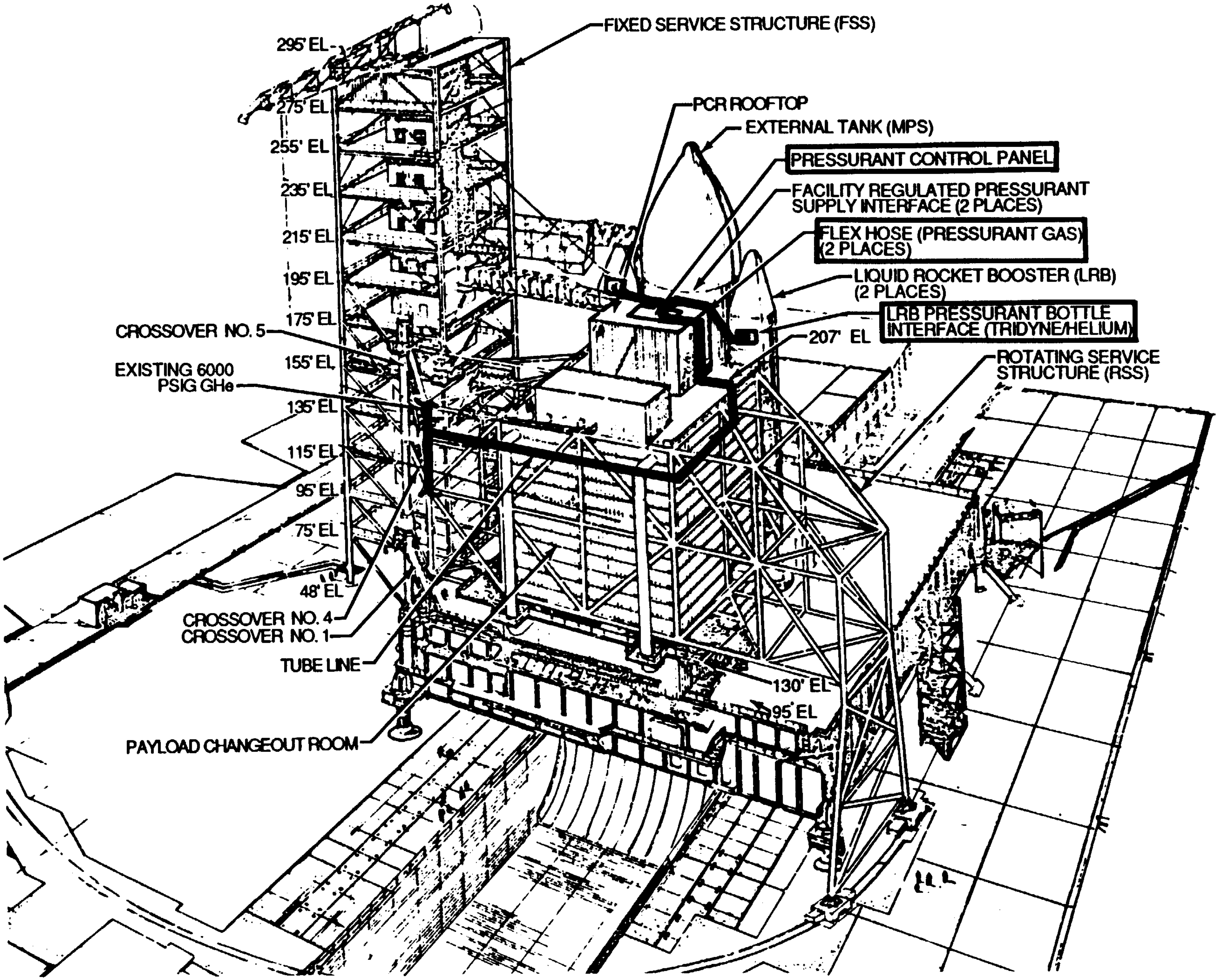
The Martin Marietta configurations use helium at 6,000 psig; GHe will be supplied to the pressurant control panel from the existing Pad high pressure gas storage facility. The GHe line already exists in the MLP and will be tapped and routed into the LRB pressurant control panel where it will be regulated, monitored, and delivered to the two LRBs.

5.4.1.2 Description of GHe Supply System/GSE

Gaseous helium is an existing commodity at the Pad. However, with the addition of the LRB pressure-fed requirement, the existing volume available will not be enough for all the systems. Supply piping and tubing already exist at the Pad FSS, RSS, and the MLP. The following are configurations of the LRB helium bottle fill systems as dictated by the LRB pressurant bottle fill interface location:

LRB bottle fill interface (forward)

(See Figure 5.4.1.2-1) The helium supply will be tapped from an existing 6,000-psig supply line already in the RSS. The new supply line will be routed to the pressurant regulation panel that will be located on the RSS rooftop. Supply helium will be regulated in a panel similar to S72-0685-01 to various pressures and delivered through a manifold, branching out to the two LRBs.For the interface located forward, this will be two panels with requirement 1 on the panel on the RSS and



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Figure 5.4.1.2-1. LRB Bottle Fill Helium Pressurant System - Forward Interface.

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requirement 2 on a panel in the MLP.

LRB bottle fill interface (aft)

(See Figure 5.4.1.2-2) A panel similar to S72-0685-01 will be required inside the MLP for aft fill and on the RSS for forward fill. Two regulation circuits will be redundant to ensure reliability, and the panel will be electrically connected to the LPS.

5.4.1.2.1 Requirements

Requirement 1: Helium Bottle Fill Circuit

The panel will receive 6,000 psig GHe from the pad high pressure storage facility and regulate it to 4,450 psig for final bottle fill. Initial bottle fill will be provided by the primary helium reduction system.

Requirement 2: Primary Helium Circuit

The 6,000-psig helium supply already in the panel is branched out to supply the primary helium pressure reduction system circuit. This circuitry reduces/regulates the 6,000-psig supply to 2,000 psig and distributes it to various branches to fulfill several requirements. One branch is connected to the helium bottle fill circuitry for bottle fill checkout and initial pressurization prior to full flight pressure; the other branch is routed to a manifold with additional branch connections dedicated to other functions.

5.4.1.3 Description of Tridyne (He, H2, O2) Supply System GSE

This is a gas compound that can be supplied by General Dynamics Corp. and transported to KSC in tubebank trailers. Delivery and control of tridyne is dictated by the location of the LRB pressurant bottle fill interface as follows:

LRB bottle fill interface located on the LRB forward segment

(See Figure 5.4.1.3-1) Tubebank trailers will be parked alongside the FSS, and tridyne gas will be conveyed from the tubebanks to the pressurant regulation panel through the flex hoses and tubings routed on the FSS and the RSS, and then into the panel conveniently located and mounted on the Payload Changeout Room (PCR) rooftop. The panel will regulate tridyne to various pressures for initial bottle fill and checkout and final fill. The regulated gas is delivered to the two LRBs through a manifold and flex hoses. An access platform is required to perform this opera-

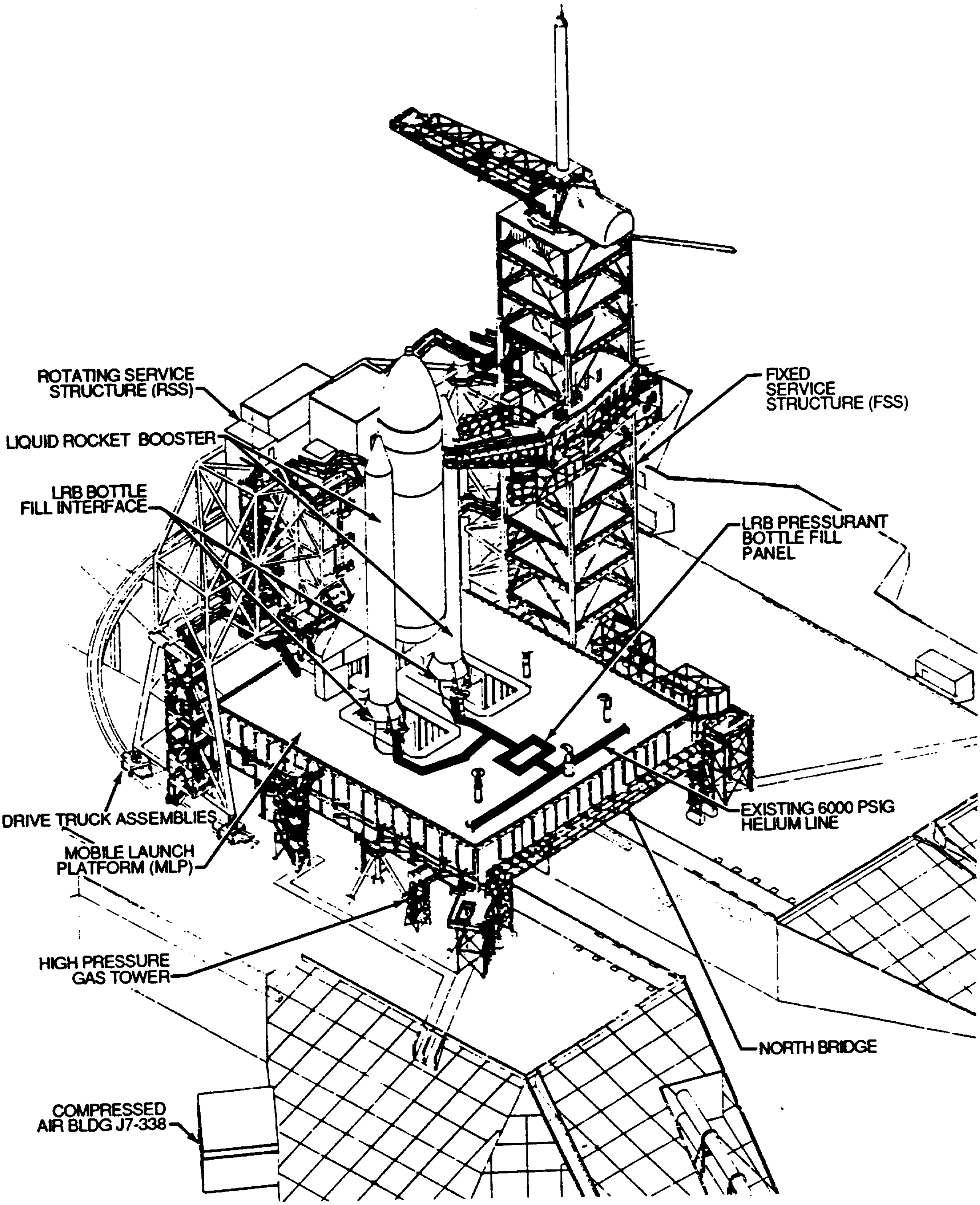
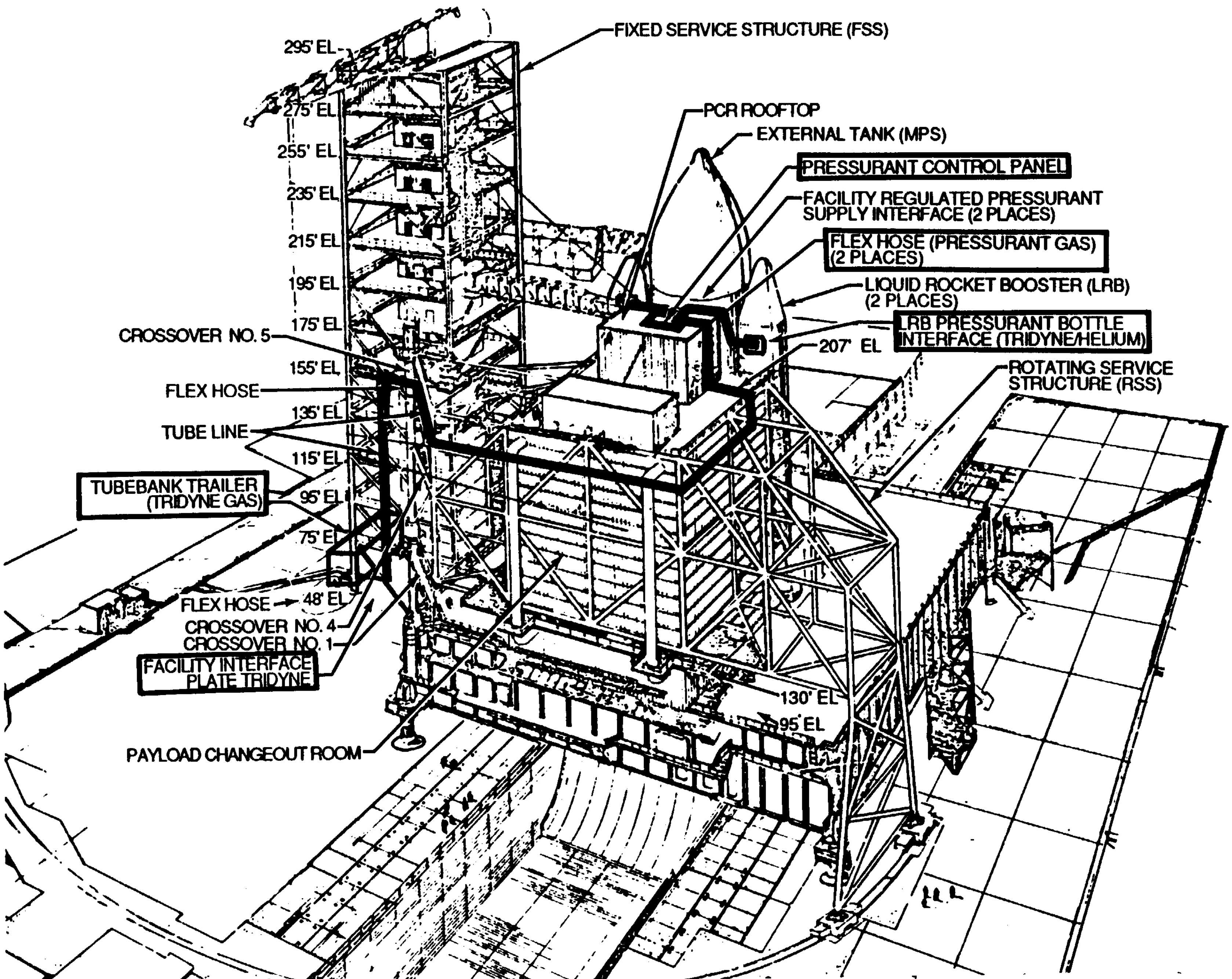


Figure 5.4.1.2-2. LRB Bottle Fill Helium Pressurant System - Aft Interface.

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Figure 5.4.1.3-1. LRB Bottle Fill Tridyne Pressurant System - Forward Interface.

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tion. The panels will be configured identically as described in Paragraph 5.4.1.2 except that bottle fill would be tridyne.

LRB bottle fill interface located on the LRB aft

(See Figure 5.4.1.3-2) Tridyne gas will be conveyed from the tubebank trailers parked in the high pressure storage facility through flex hoses and tubelines routed in the pad trench, high pressure gas tower and into the MLP and connected to the pressure regulation panel. The gas will be regulated in the panel to various pressures for checkout, initial fill, and final bottle pressurization. The gas will be delivered through a manifold branch-out to the two LRBs. The panel will be configured identically as described in Paragraph 5.4.1.2 except that bottle fill will be tridyne.

5.4.1.4 Conclusions/Recommendations

If the LRB bottle fill interface is located on the LRB forward segment, the pressure regulation will be done with the panel mounted on the PCR rooftop.

If helium is used for the LRB pressurization system, the helium high pressure storage battery should be expanded. Addition of 10 high pressure storage bottles with a capacity of 200 cubic feet is recommended.

If tridyne is used for the LRB pressurization system, a minimum of tubebank trailers (assuming each tubebank trailer capacity is 200 cubic feet) is recommended. Helium should be used with the LRB pressure-fed system. It is an existing and known commodity, and distribution lines are already in place.

The onboard pressurant bottle fill interface should be located on the aft segment of the LRB for convenience and less interference with other Shuttle systems.

5.4.2 Propellant System GSE

This section defines the GSE required for each of the propellant options. Since the Pad and MLP equipment functions as a system, this section will treat the propellant requirements as a total system and include definitions for the Pad and the MLP.

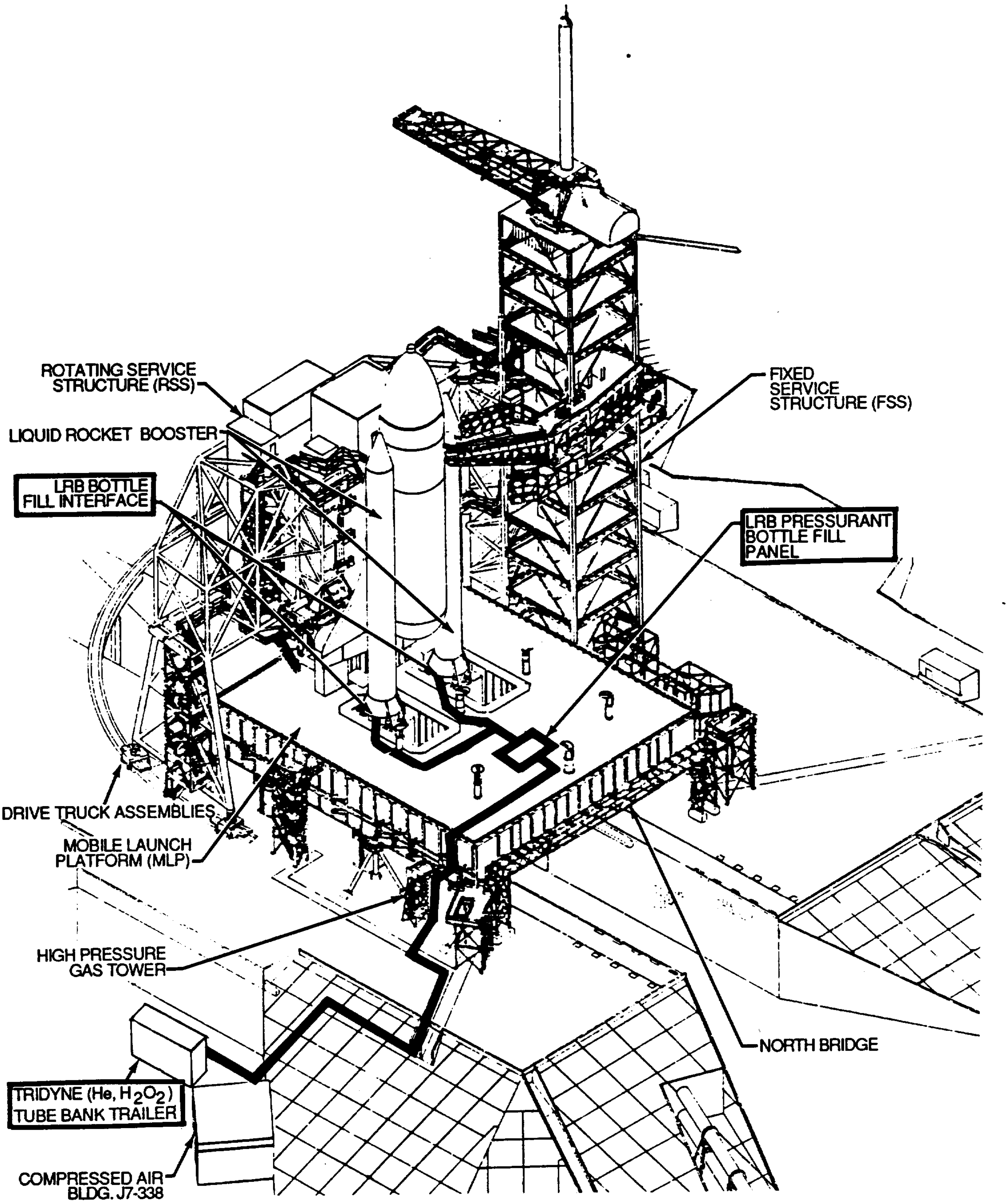


Figure 5.4.1.3-2. LRB Bottle Fill Tridyne Pressurant System - Aft Interface.

5.4.2.1 LRB LOX System Fluid GSE Requirements for Pad/MLP

This section will define and identify the necessary system GSE to support the LOX Fill and Drain system in the MLP and at the Pads.

The pneumatic system will include nitrogen and helium pneumatic distribution systems. Nitrogen will be used for remote operation of valves and in the purge system to protect facility lines, components, and equipment from moisture and contamination. Nitrogen will be supplied for blanket pressure when the LOX system is in standby configuration, and for leak check of system connections. Helium will be used for LRB LOX tank anti-geysering, pre-pressurization and vent valve opening actuation. It will also be used for LRB/ umbilical anti-icing. (See Figure 5.4.2.1)

Helium Anti-Ice Panel (MLP)
This panel will be used to supply heated GHe during prepressurization of the LOX tank to prevent icing of the prepressurization line. 6000 psig helium will be reduced to 750 psig and then to 200 psig, and will be passed through a 15 kW heater before being distributed through solenoid control valves to The LOX prepress lines. This panel will be similar to the Orbiter Helium Anti-ice Panel, PMN S72-0685-05.

LOX Tank Pressure and GH2 Purge Panel (MLP)
This panel will route the 2000 psig helium received from the primary GHe pressure reduction and helium bottle fill panel through an orifice (reduced-flow pressure) to the LOX transfer line. There, the GHe will be used for drain assist, engine purge, and leak check. Gas under 750 psig from the GN2 Facility Regulation Panel will also be routed to the LOX transfer line for drain assist, engine purge, and leak check functions.

GH2 at 750 psig and 3000 psig from the GN2 facility regulation panel will be routed for umbilical carrier plate purge, trickle purge, operational purge , standby pressure, LOX tank prepressure, LOX tank purge, and pressure drain functions. This panel will be located in The MLP. This panel is new, yet similar to the Orbiter's LOX tank pressure and GN2 Purge Panel (S70-0685-03).

LOX Control and Purge System Panel (MLP)
This panel will route 750 psig unregulated GN2 from The GN2 Facility Regulation Panel to solenoid valves to control actuating pressure for the LOX main fill valve, drain valve, engine bleed valve, and vent valve. This pressure will also be used for the LOX fill and drain at the valve

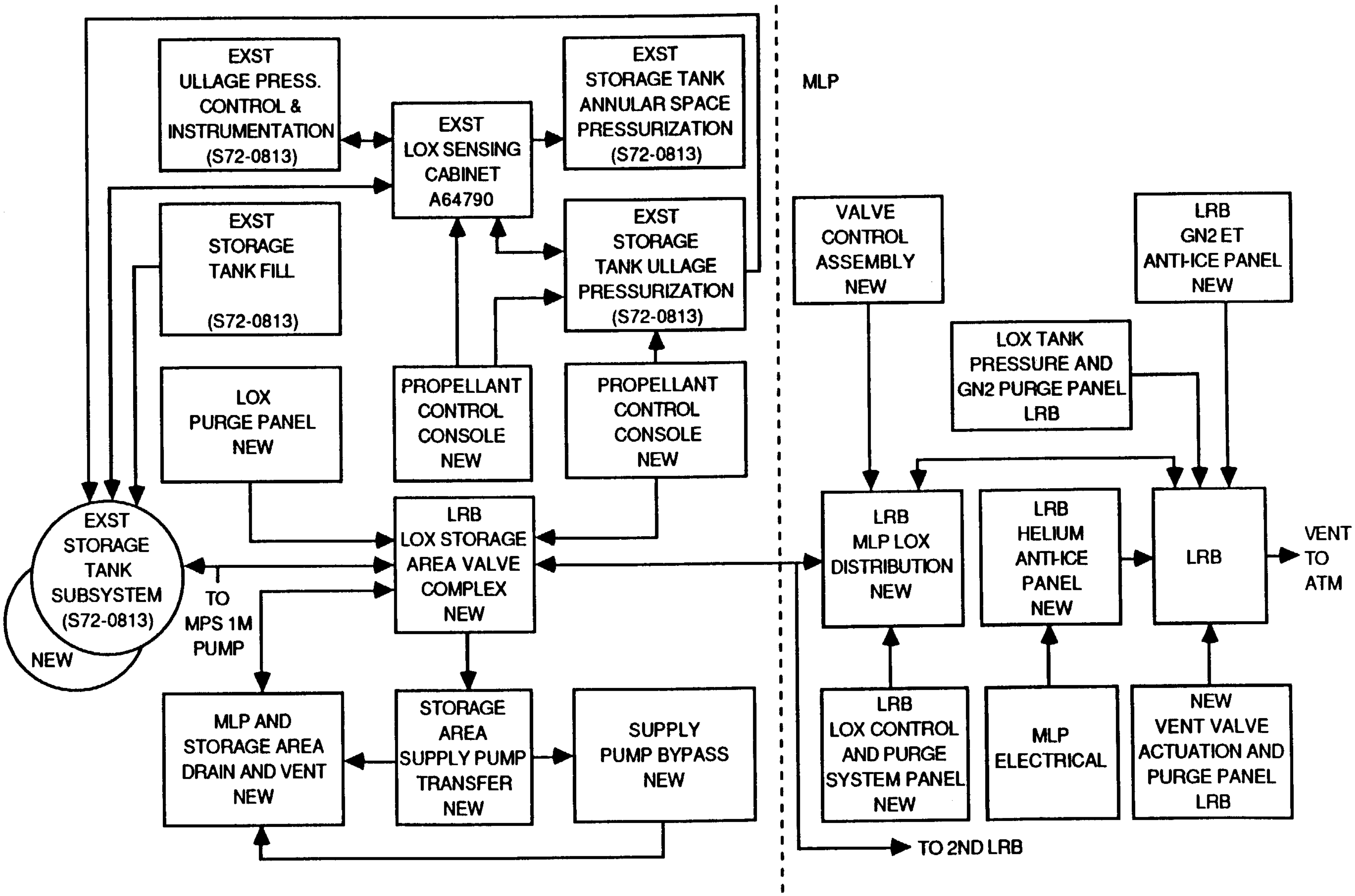


Figure 5.4.2.1. LRB LOX System Block Diagram.

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complex and umbilical leak checks.

This panel will reduce 750 psig inlet pressure to 50 psig and will route it to the LOX transfer line. It will also regulate 750 psig to provide blanket pressures for the fill and drain lines at the valve complex this panel will be similar to the Shuttle's LOX Control and Purge System Panel (S72-1107-03).

GN2 LRB Anti-Icing Panel (MLP)

The function of this panel will be to deliver hot gases to the LRB nose cone area. The nose cone 3000-psig pressure nitrogen will be received from the FSS GN2 Facility panel . This pressure will be reduced to working pressures of 1900 psig in a primary leg and to 2000 psig in the secondary leg of a redundant subsystem. The GN2 will then heated by an 18-kW heater and will be routed to the nose cone at 200° F. This panel also will provide 50 psig GN2 pressure for electrical distribution and electrical 4-kW and 18-kW controller boxes. This panel will be similar to the GN2 ET Anti-ice Panel (S72-0694-17).

Vent Valve Actuation and Purge Panel (MLP)

The function of this panel will be to supply GHe to two locations on the LRB LOX tank. GHe at 750 psig will be supplied to the panel and be distributed through solenoid control valves to the vehicle interface for LOX tank vent valve actuation. Another circuit of the panel controls and will regulate the helium to be distributed to the LOX tank interface for helium bubbling. This panel will be similar in design to the ET vent Valve Actuation and Purge Panel (S72-0697-08).

LOX Valve Skid (MLP)

The function of the valve skid will be to control the LOX flow to the LRB. Two skids will be required. The skid will contain a fast fill circuit as well as a replenish valve circuit. The skid will be vacuum jacketed and the design will be similar to the existing Main Propulsion System (MPS) LOX skid. (PMN S72-0814)

LOX Storage Facility

The storage area will be modified to add a second storage vessel, LRB LOX pumps, and a new crosscountry line. (See Section 11 of Volume III)

5.4.2.2 LRB LH2 System Fluid GSE Requirements for Pad/MLP

This section will define and identify the necessary system GSE to support the LH2 Fill and Drain system in the MLP and at the Pads.

The pneumatic panels for the LH2 LRB System control the pneumatically operated cryogenic valves, provide and control timely purges of the transfer components, provide a GN2 purge to the intertank, operate the LH2 tank vent valves, pressurize the vehicle LH2 tank in preparation for flight, heat and control helium gas for LRB component de-icing and, finally , blanket- pressurize the LH2 System for protection when it is not in use. (See figure 5.4.2.2)

LH2 Propellant Control Console (Storage Area)

The existing propellant control console will have manually operated, panel-mounted valves which supply operating pressure for storage areas flow control valves. Remote control of storage area flow control valves and vent valves will be accomplished by solenoid valves in the propellant control console. Modification of this panel will be required to accommodate the second storage vessel.

Helium Purge Panel (Storage Area)

A 3000-psig helium input will be reduced to 100 psig to supply the vaporizer purge panel and the emergency vaporizer purge panel. A second panel will be required to accommodate the second storage vessel and vaporizer. This panel will be similar to the LH2 Storage Area Helium Purge.

Vaporizer Purge Panel (Storage Area)

The storage area purge panel provides nitrogen and helium gases to inert the fill manifold and the vaporizers. The panel also supplies nitrogen pressure to the main vaporizer pressure controller. A second panel will be required to accommodate the new vaporizer. This panel is similar to the LH2 propellant storage and loading system panel. (PMN K60-0067)

Emergency Vaporizer Purge Panel

If the vaporizer purge panel is inaccessible due to dangerous conditions, the emergency vaporizer purge panel is used to safe the system. A second panel will be required. This panel will be similar to the LH2 propellant storage and loading system. (PMN K60-0069)

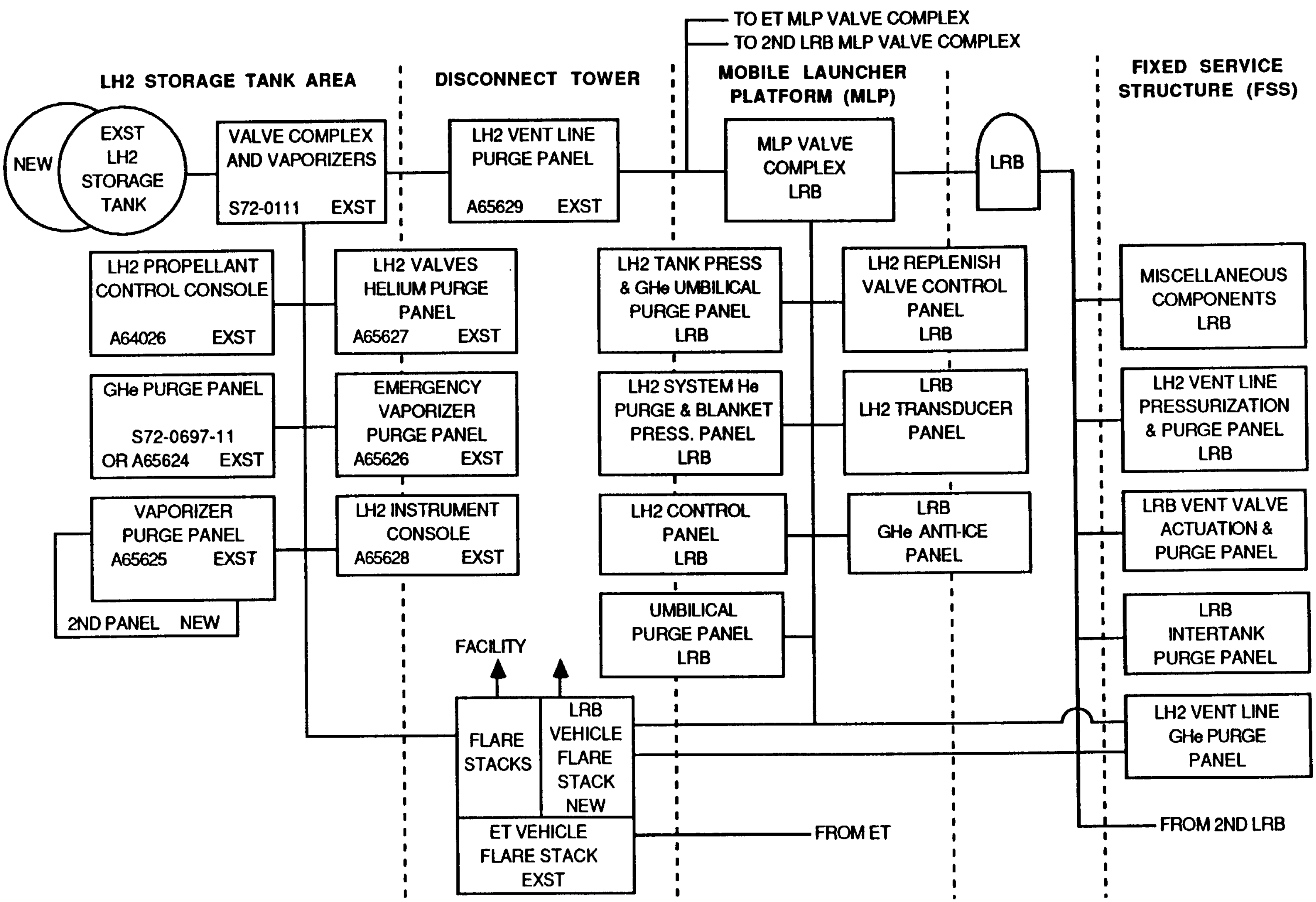


Figure 5.4.2.2. LRB LH2 Block Diagram.

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LH2 Valves Helium Purge Panel (Storage Area)

The helium purge panel provides 70-psig helium to the lantern ring packing ports of several LH2 valves. This purge prevents the leakage of GH2 when high flow rates are experienced. The panel (PMN K60-0068) will require modification to accommodate the new storage vessel and piping.

Instrument Console (Storage Area)

The LH2 instrument console has a liquid level gage, ullage pressure gage, and a pressure controller. The liquid level gage indicates LH2 level in the storage tank. The ullage pressure gage indicates storage tank ullage pressure. The pressure controller, receiving a signal of storage tank ullage pressure, regulates LH2 flow to the main vaporizer in order to maintain the storage tank ullage within the desired operating range. Transducers transmit ullage pressure and liquid level signals for remote display in the LCC. A second panel will be required to accommodate the second storage vessel. This panel will be similar to the LH2 propellant storage and loading system. (PMN K60-0071)

LH2 Vent Line GHe Purge Panel (Pad Surface)

The vent line purge panel is located at the base of the LH2 disconnect tower. The 3000-psig GHe is reduced to 120 psig to supply purge GHe to the MLP facility and vent lines. This panel will be sufficient. (PMN S72-0697-13)

LH2 Tank Pressurization and Umbilical Purge Panel (MLP)

This panel will require a facility source of 2000 psig helium to distribute 2000 psig helium separately through restricting orifices for LH2 tank pressurization, LH2 transfer line purges and drain assist purposes. The 2000-psig helium supply can be regulated to lower pressures and distributed through an orifice for umbilical purge requirements and provide backup pressurization to the LOX pressurization panel for anti-icing of the LOX pre-pressurization line. This panel should also have a 750-psig nitrogen supply through an orifice to provide a trickle purge for the LH2 umbilical purge line when helium is not required.

This panel will be new, similar to the ET LH2 Tank Pressurization and Umbilical Purge Panel, PMN S72-0685-02).

LH2 System Helium Purge and Blanket Pressure (MLP)

GHe at 6000 psig will be supplied to this panel and reduced to 3000 psig. It will be further reduced to 750 psig and distributed for MLP vent line purges and purges for LH2 fill line between MLP

valve complex and storage area. The 750-psig GHe will be reduced to 80 psig to provide helium to the MLP valve lantern ring packing ports. This will prevent leakage of GH2 when high flow rates are experienced. The 750 psig will be further reduced for locally controlled blanket purges.

This panel will be similar to the ET propellant storage and loading system. (PMN S72-0685-04)

LH2 Control Panel (MLP)

GN2 will be filtered and distributed to a solenoid valve complex which supplies control pressure for the main fill, auxiliary fill, TSM drain, and auxiliary TSM drain pneumatically operated valves. Filtered 750 psig GN2 will also be supplied to the LH2 replenish valve control panel. This panel will be similar to the ET propellant storage and loading system, PMN S72-1107-04.

LOX/LH2 Purge Panel (MLP)

The MLP LH2 and LOX purge panel will provide a GN2 purge flow to the liftoff umbilical during hydrogen loading and purges for various camera mounts on the MLP. This panel will be similar to the LH2/LOX TSM Purge Panel, PMN S72-1107-09.

Replenish Valve Panel (MLP)

A replenish valve will be operated by the electropneumatic valve control assembly. The assembly will position the valve so that LH2 replenish balances the LH2 boiloff. The LPS will control the electropneumatic control assembly in conjunction with the liquid level sensors of the LH2 tank. This panel will be similar to the LH2 Replenish Valve Panel. (PMN K60-0062)

Helium Anti-Ice Panel (MLP)

This panel will be used to supply heated GHe during prepressurization of the LH2 tank to prevent icing of the prepressurization line. 6000 psig helium will be reduced to 750 psig and then to 200 psig, and will be passed through a 15-kW heater before being distributed through solenoid control valves to the LH2 prepress lines. This panel will be similar to the Orbiter Helium Anti-ice Panel, PMN S72-0685-05.

Intertank Purge Panel (MLP)

The LRB intertank purge panel will provide GHe to the intertank compartment to prevent condensation of moisture, to provide a thermal conditioning of electrical subsystem, and to avoid a buildup of hazardous gases. Two 100-kW heaters downstream of this panel will prevent ice formation of the outer surface of the LRB. Another circuit will supply and control the pressure

that will actuate the ground LH2 tank vent valve. This panel will be similar to the ET intertank purge panel, PMN S72-0694-01.

LH2 Vent Line Pressurization and Purge Panel (MLP)

This panel will contain the solenoid-operated control valves which will supply the helium to purge the LH2 vent line and flexhose line as well as provide a trickle purge for the LH2 vent line. This panel will be similar to the LH2 Vent Line Pressurization and Purge Panel, PMN S72-0697-02.

Vent Valve Actuation and Purge Panel (MLP)

The function of this panel will be to supply GHe to two locations on the LRB LH2 tank. GHe at 750 psig will be supplied to the panel, and this panel will be used to distribute the helium through solenoid control valves to the pneumatically operated LH2 tank vent valve for actuation gas as well as to the LOX vent valve and helium bubbling system. This panel will be similar in design to the ET Vent Valve Actuation and Purge Panel, (S72-0697-08).

LH2 Valve Skid (MLP)

The function of the valve skid will be to control the LH2 flow to the LRB. Two skids will be required and will connect to the existing MPS system upstream of the MPS valve skid. The skid will contain a fast fill circuit as well as a replenish valve circuit. The skid will be vacuum jacketed and the design will be similar to the existing MPS LH2 skid.(PMN S72-0109)

LH2 Storage Facility

The storage area will be modified to add a second storage vessel and connecting piping and control valves (See Section 11 of Volume III).

5.4.2.3 LRB RP-1 System Fluid GSE Requirements for PAD/MLP

This section will define and identify the necessary system GSE to support the LRB RP1 Propellant Loading System at the Launch Pad and in the MLP.

This report assumes that the LRB RP-1 system would be similar to the Apollo RP-1 propellant loading system. The propellant will be stored at the launch Pad and be transferred to the vehicle fuel tank using pumps.

The valve complexes will require control panels and consoles consisting of pneumatically operat-

ed valves to provide control of the transfer components, operate the LRB RP-1 tank vent valves, pressurize the vehicle RP-1 tank in preparation for flight, and provide blanket pressures for the system for moisture protection when the system is not in use.

A block diagram depicting the systems discussed in this report is shown in Figure 5.4.2.3.

RP-1 Propellant Control Console (Storage Area)

The storage propellant control console will have manually operated, panel mounted valves which will regulate 3000 psig facility supply to 750 psig to distribute via remotely operated solenoid valves to the storage valve complex for actuation of the pneumatic operated valves. The 3000-psig nitrogen will also be regulated for distribution at low pressures to a RP-1 facility purge panel.

RP-1 Facility Purge Panel (Storage Area)

The storage facility purge panel will have manually operated, panel mounted valves which will regulate the low pressure nitrogen gas delivered from the propellant control panel for purging the storage area tank ullage during loading operations, providing a moisture protection blanket for the storage fill and draining the hard-line piping system.

RP-1 System GN2 Purge and Blanket Press. Panel (MLP)

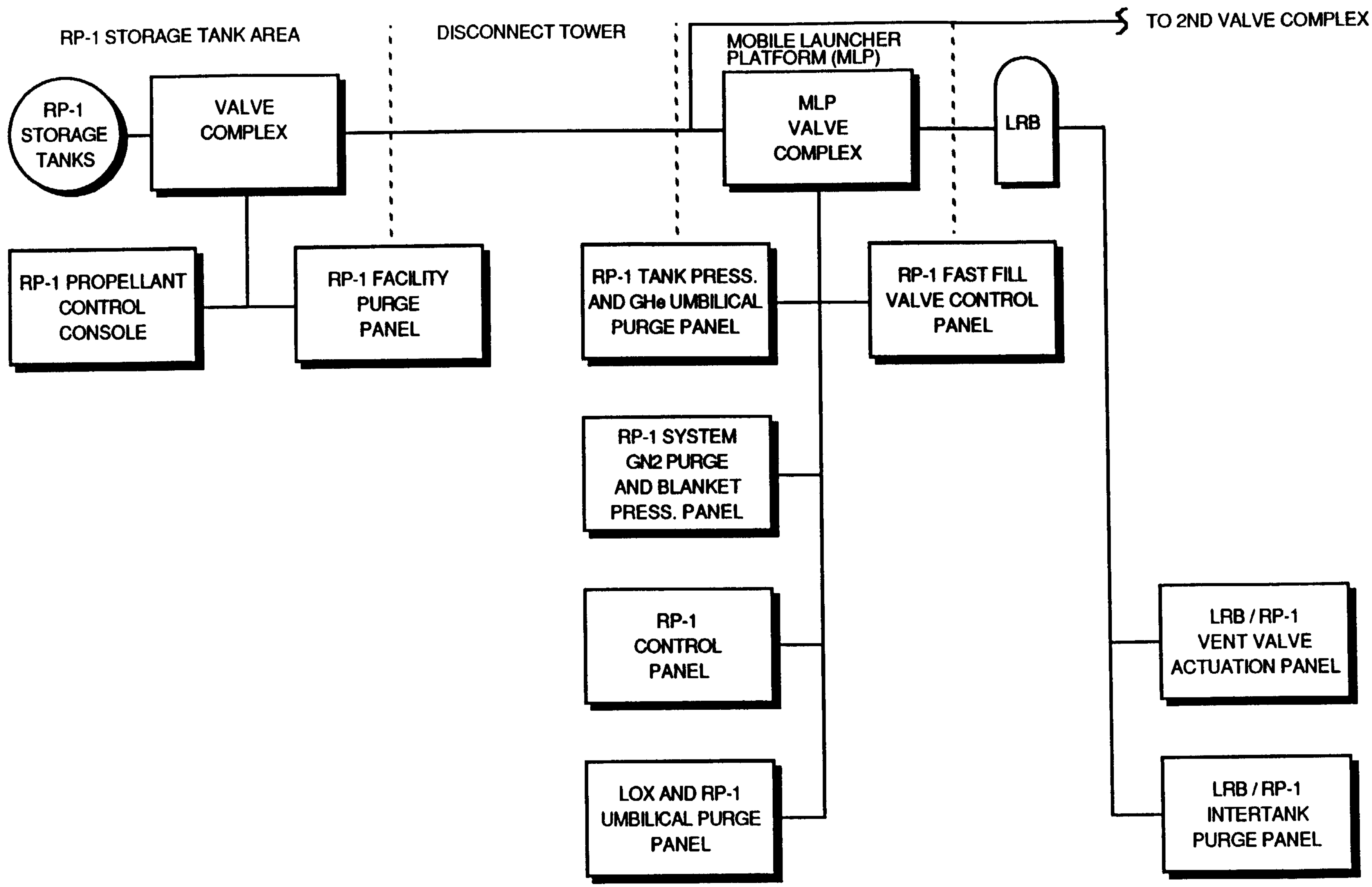
This GN2 purge panel will support the pneumatic requirements of the RP-1 vehicle loading valve complex. It will have manually operated, panel-mounted valves which will regulate facility low pressure nitrogen gas for purging the LRB RP-1 loading valve complex, providing a moisture protection blanket for the hard-line piping system.

RP-1 Control Panel (MLP)

This control panel will support the pneumatic requirements of the vehicle loading valve complex. It will have manually operated, panel-mounted valves which will require a 750-psig facility supply for distribution via remotely operated solenoid valves for actuation of the pneumatically operated valves. This panel may also provide 750 psig to the Fast FIll Valve Control Assembly since both panels will service the same valve complex.

Fast Fill Valve Control Assembly (MLP)

This assembly will receive nominal 750-psig nitrogen gas via the RP-1 valve control panel or another facility source and will be distributed through redundant regulation circuits, one automat-



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Figure 5.4.2.3. LRB RP-1 System Block Diagram of GSE.

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ic control and the other, manual control for operation of the pneumatically operated RP-1 fast fill valve.

RP-1 Tank Pressurization and Umbilical Purge Panel (MLP)
This panel will require high pressure facility source of helium for distribution through restricting orifices for RP-1 tank pressurization. The high pressure helium supply will be regulated to lower pressures and distributed through orifices for umbilical purge requirements and to provide backup pressurization to the LOX pressurization panel for anti-icing of the LOX prepressurization line.

Intertank Purge Panel (MLP)
The LRB intertank purge panel will provide GHe to the intertank compartment to prevent condensation of moisture, to provide a thermal conditioning of electrical subsystem, and to avoid a buildup of hazardous gases. Two 100-kW heaters downstream of this panel will prevent ice formation of the outer surface of the LRB.

Vent Valve Actuation and Purge Panel (MLP)
The function of this panel will be to actuate the LRB RP-1 fuel tank vent valves. GHe at 750 psig will be supplied to the panel and be distributed via remotely operated solenoid valves to the interface of the vehicle for tank vent valve actuation.

RP-1 Valve Skid (MLP)
The function of the valve skid will be to control the RP-1 flow to the LRB. Two skids will be required. The skid will contain a fast fill circuit and slow fill circuit. The skid will have insulated piping and be schematically similar to the MPS LOX skid.

RP-1 Storage Facility
The storage area will be equipped with three storage vessels, a valve skid, and a pump similar to the original Apollo design, (see Section 11 of Volume III).

5.4.2.4 LRB LCH4 System Fluid GSE Requirements for Pad/MLP

This section will define and identify the necessary system GSE to support the LCH4 Fill and Drain system in the MLP and at the Pads.

The pneumatic panels for the LCH4 LRB system control the pneumatically operated cryogenic

valves, provide and control timely purges of the transfer components, provide a GN2 purge to the intertank, operate the LCH4 tank vent valves, pressurize the vehicle LCH4 tank in preparation for flight, heat and control helium gas for LRB component de-icing and, finally, blanket-pressurize the LCH4 system for protection when it is not in use. (See Figure 5.4.2.4)

LCH4 Propellant Control Console (Storage Area)

The propellant control console will have manually operated, panel-mounted valves which supply operating pressure for storage areas flow control valves. Remote control of storage area flow control valves and vent valves will be accomplished by solenoid valves in the propellant control console. This panel will be similar to the LH2 propellant Control Console. (PMN K60-0070)

Helium Purge Panel (Storage Area)

A 3000-psig helium input will be reduced to 100 psig to supply the vaporizer purge panel and the emergency vaporizer purge panel. This panel will be similar to the LH2 Storage Area Helium Purge Panel (PMN S72-0697-11)

Vaporizer Purge Panel (Storage Area)

The storage area purge panel will provide nitrogen and helium gases to inert the fill manifold and the vaporizers. The panel will also supply nitrogen pressure to the main vaporizer pressure controller. This panel will be similar to the ET Propellant storage and loading system panel. (PMN K60-0067)

Emergency Vaporizer Purge Panel (Storage Area)

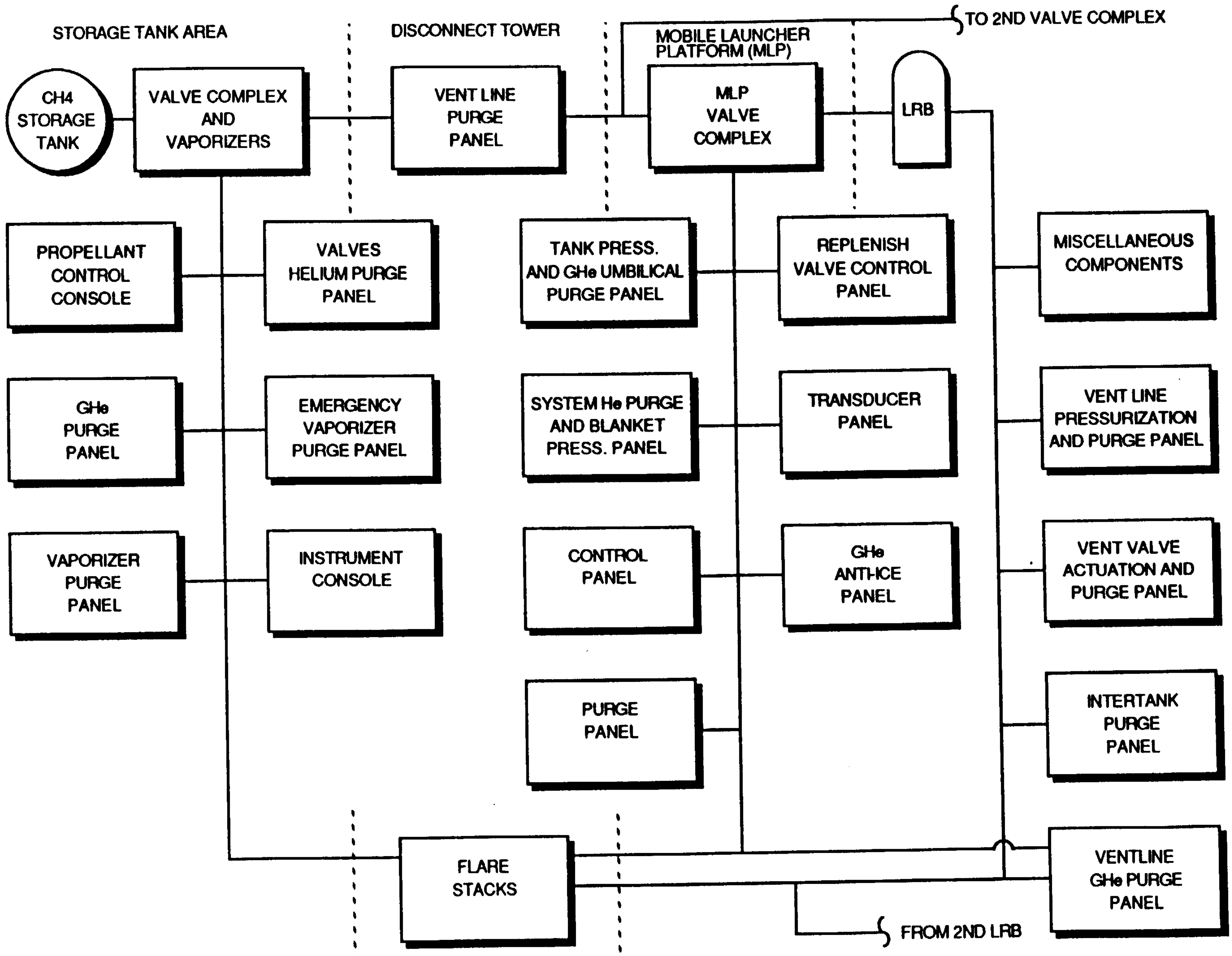
If the vaporizer purge panel is inaccessible due to dangerous conditions, the emergency vaporizer purge panel will be used to safe the system. This panel will be similar to the LH2 ET propellant storage and loading system.(PMN K60-0069)

LCH4 Valves Helium Purge Panel

The helium purge panel will provide 70-psig helium to the lantern ring packing ports of several LCH4 valves. This purge will prevent the leakage of GH2 when high flow rates are experienced. This panel will be similar to the LH2 propellant storage and loading system. (PMN K60-0068)

Instrument Console (Storage Area)

The LCH4 instrument console will have a liquid level gage, a ullage pressure gage, and a pressure controller. The liquid level gage will indicate LCH4 level in the storage tank. The ullage pressure



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Figure 5.4.2.4. LRB CH4 System Block Diagram Of GSE.

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gage will indicate storage tank ullage pressure. The pressure controller, receiving a signal of storage tank ullage pressure, will regulate LCH4 flow to the main vaporizer in order to maintain the storage tank ullage within the desired operating range. Transducers will transmit ullage pressure and liquid level signals for remote display in the LCC. This panel will be similar to the LH2 propellant storage and loading system. (PMN K60-0071)

LCH4 Vent Line Purge Panel (Pad Surface)

The vent line purge panel will be located at the base of the LCH4 disconnect tower. The 3000 psig GN2 will be reduced to 120 psig to supply purge GN2 to the MLP facility and vent lines. This panel will be similar to the LH2 propellant storage and loading system. (PMN S72-0697-13)

LCH4 Tank Pressurization and Umbilical Purge Panel (MLP)

This panel will require a facility source of 2000-psig helium to distribute helium through orifices for LCH4 tank pressurization, LCH4 transfer line purges and vehicle drain assist pressurization. The 2000-psig helium supply will be regulated to lower pressures, distributed through an orifice for umbilical purge requirements, and provide backup pressurization to the LOX pressurization panel for anti-icing of the LOX prepressurization line.

This panel will also have a 750-psig nitrogen supply through an orifice to provide a trickle purge for the LCH4 umbilical purge line when helium is not required. This panel will be new, similar to the LH2 Tank Pressurization and Umbilical Purge Panel. (PMN S72-0685-02)

CH4 System Helium Purge and Blanket Pressure (MLP)

GHe at 6000 psig will be supplied to this panel and reduced to 3000 psig. It will be further reduced to 750 psig and distributed for MLP vent line purges and purges for LCH4 fill line between MLP valve complex and storage area. The 750-psig GHe will be reduced to 80 psig to provide helium to the MLP valve lantern ring packing ports. This will prevent leakage of GH2 when high flow rates are experienced. The 750 psig will be further reduced for locally controlled blanket purges. This panel will be similar to the ET propellant storage and loading system, PMN S72-0685-04.

LCH4 Control Panel (MLP)

GN2 will be filtered and distributed to a solenoid valve complex which will supply control pressure for the main fill, auxiliary fill, TSM drain, and auxiliary TSM drain pneumatically operated valves. Filtered 750-psig GN2 will also be supplied to the LCH4 replenish valve control panel. This panel will be similar to the ET propellant storage and loading system, PMN S72-1107-04.

LOX/LCH4 Purge Panel (MLP)

The MLP LCH4 and LOX tunnel purge panel will provide a GN2 purge flow to the lift-off umbilicals during methane loading and purges for various camera mounts on the MLP. This panel will be similar to the LH2/LOX TSM Purge Panel, PMN S72-1107-09.

Replenish Valve Panel (MLP)

A replenish valve will be operated by the electropneumatic valve control assembly. The assembly will position the valve so that LCH4 replenish balances the LCH4 boil off. The LPS will control the electropneumatic control assembly in conjunction with the liquid level sensors of the CH4 tank. This panel will be similar to the LCH2 Replenish Valve Panel (PMN K60-0062).

Helium Anti-Ice Panel (MLP)

This panel will be used to supply heated GHe during prepressurization of the LCH4 tank to prevent icing of the prepressurization line. 6000-psig helium will be reduced to 750 psig and then to 200 psig, and will be passed through a 15-kW heater before being distributed through solenoid control valves to the LCH4 prepress lines. This panel will be similar to the Orbiter Helium Anti-Ice Panel, PMN S72-0685-05.

Intertank Purge Panel (MLP)

The LRB intertank purge panel will provide GHe to the intertank compartment to prevent condensation of moisture, to provide a thermal conditioning of electrical subsystem, and to avoid a buildup of hazardous gases. Two 100-kW heaters downstream of this panel will prevent ice formation of the outer surface of the LRB. Another circuit will supply and control the pressure that actuates the ground LCH4 tank vent valve. This panel will be similar to the ET intertank purge panel, PMN S72-0694-01.

CH4 Vent Line Pressurization and Purge Panel (MLP)

This panel will contain the solenoid-operated control valves which supply the helium to purge the LCH4 tank hard vent line and flex hose line as well as providing a trickle purge for the LCH4 vent line. This panel will be similar to the LH2 Vent Line Pressurization and Purge Panel, PMN S72-0697-02.

Vent Valve Actuation and Purge Panel (MLP)

This panel will supply GHe to two locations on the LRB LCH4 tank. GHe at 750 psig will be supplied to the panel, which will be used to distribute the helium through solenoid control valves to

the pneumatically operated LCH4 tank vent valve for actuation gas as well as the LOX vent valve and helium bubbling system. This panel will be similar in design to the ET Vent Valve Actuation and Purge Panel (S72-0697-08).

LCH4 Valve Skid (MLP)

The function of the valve skid will be to control the LCH4 to the LRB. Two skids will be required. The skids will contain a fastfill circuit as well as a replenish valve circuit. The skid will be vacuum jacketed and the design will be similar to the existing MPS LOX skids. (PMN S72-0813 and PMN S72-0814)

CH4 Flare Stack

Due to the hazardous nature of CH4, a flare stack similar to the Pad LH2 flare stack will be required. (PMN K61-0144)

LCH4 Storage Facility

The storage area will be equipped with storage vessels, a valve skid, and pumps similar to the existing LOX storage facility. The exception will be that the vented CH4 will be captured and routed to the LCH4 flare stack. (See Section 11 of Volume III)

5.4.3 LRB Propellant System Electrical GSE Requirements for Pad

This section will establish the electrical controls necessary to perform LRB propellant tanking and storage capabilities at the launch pad/storage area.

5.4.3.1 Requirements

The Launch Pad propellant storage areas will be equipped with LPS controlled electrical hardware and monitoring equipment. This equipment will control all necessary Pad functions related to LRB propellant tanking operations. All equipment will be designed to provide for the monitoring of these control devices to assure that proper sequencing has occurred. These requirements are derived from the design of the existing LH2 system with the addition of pumps for RP-1, LOX, and LCH4 systems. The equivalent design will provide for the monitoring of other devices for such measurements as temperature, pressure, and control of valves, pump RPM, etc. Figure 5.4.3.1-1 shows the concept for the LOX system and Figure 5.4.3.1-2 shows the RP-1 system.

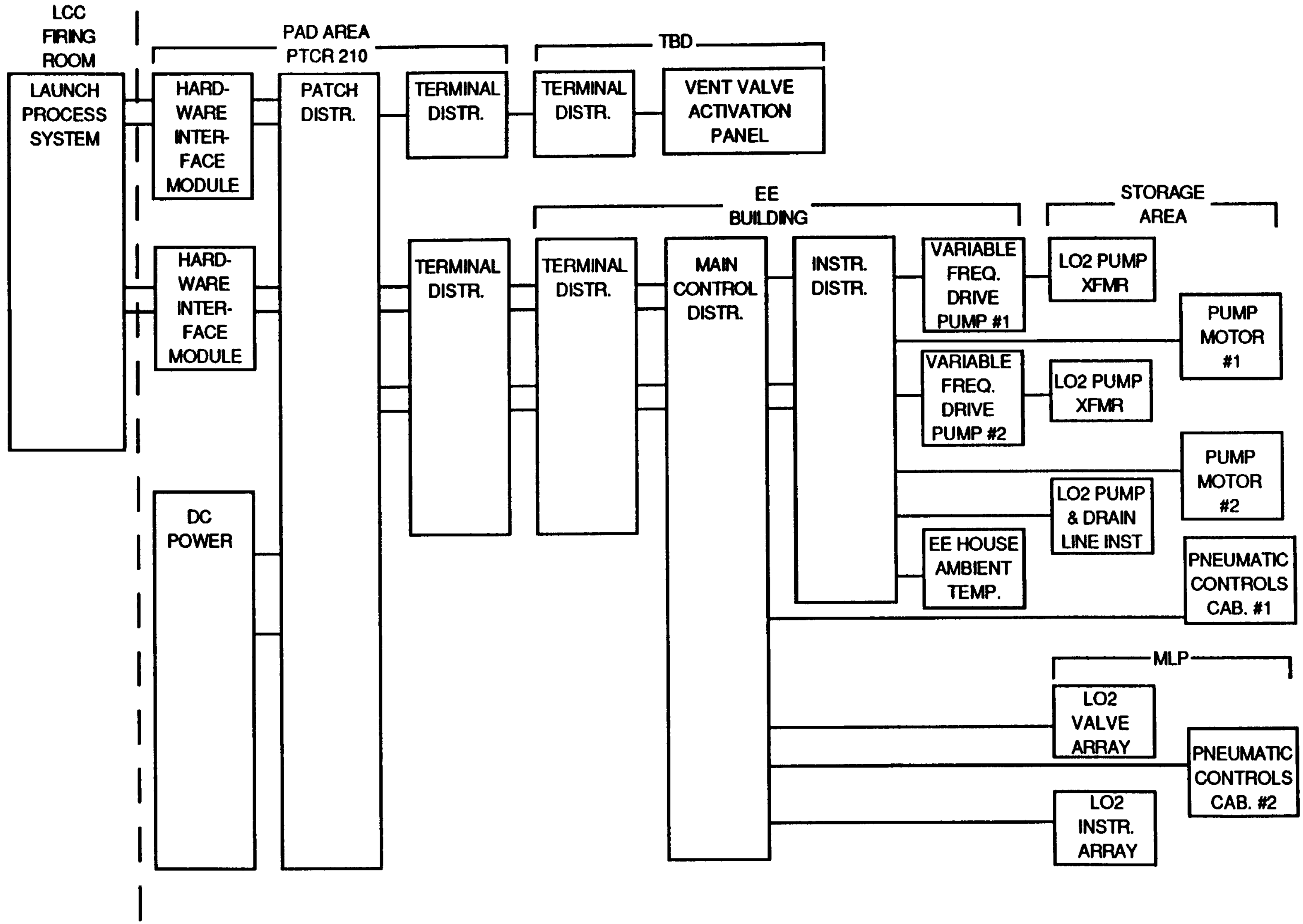


Figure 5.4.3.1-1. LRB LO2 Pad and Storage Area - GSE Electrical Controls.

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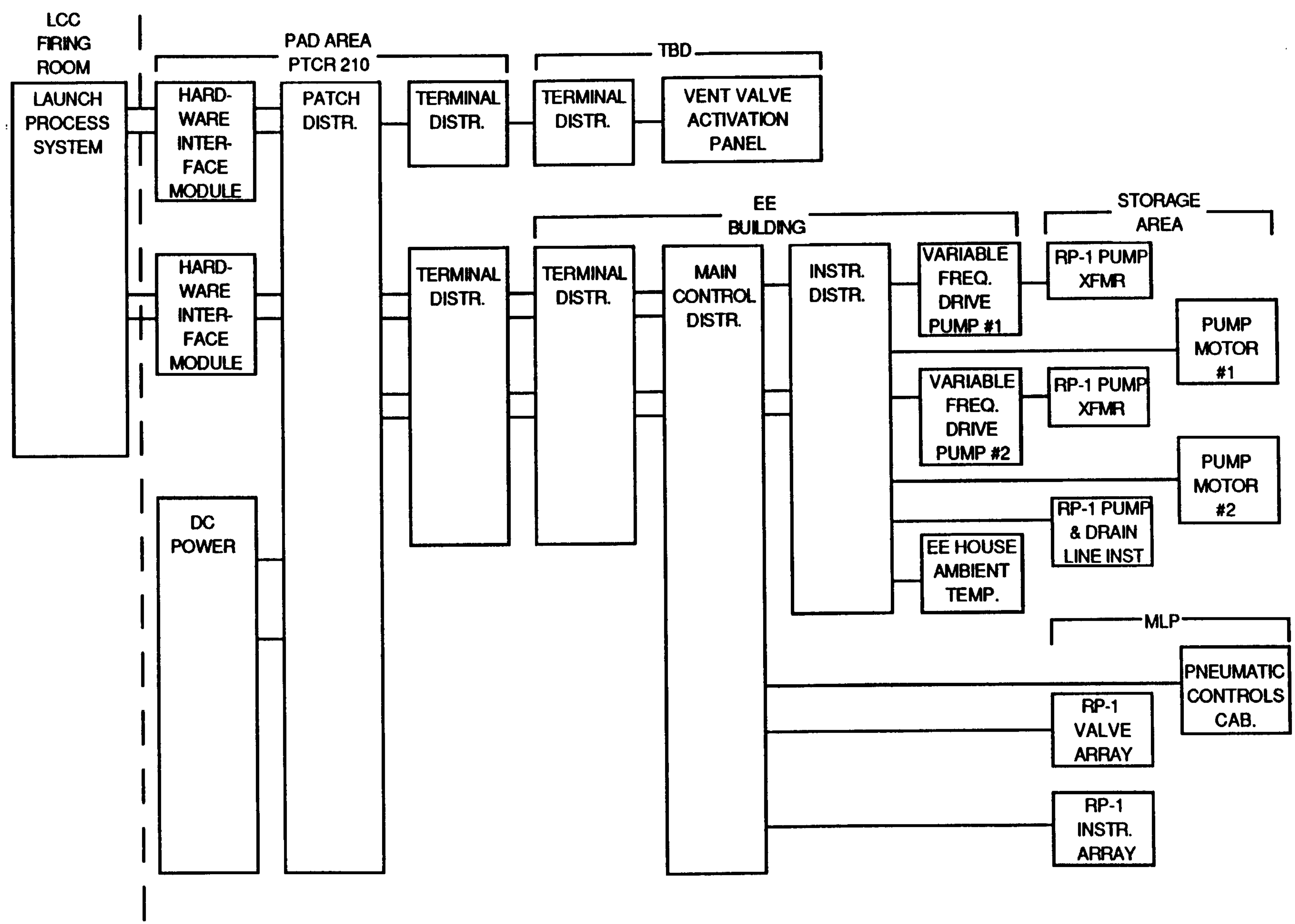


Figure 5.4.3.1-2. LRB RP-1 Pad And Storage Area - GSE - Electrical Controls.

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These electrical controls will be similar to those used in the existing LO2/LH2 systems. The type of electrical equipment will be basically the same, but the functions, monitoring information and measurements will be different for an RP-1 commodity. For LCH4 the electrical equipment will be basically the same as LOX except for the flare-stack which will be like LH2.

5.4.3.2 Conclusions/Recommendations

Implementation of the RP-1 or LCH2 system or expansion of the LOX system can be accomplished without any major problems.

The new LOX, RP-1, or LCH4 pumps will use 3-phase induction at motor drives; special enclosures are not anticipated. AC induction motors are of simple construction, require very little maintenance, and are very efficient. Each pump motor is to be microprocessor controlled and completely solid state, similar to the existing LOX 1M pumps. This feature will ensure precise motor control and the ability to monitor more external functions within the circuit to aid in trouble shooting.

All motor operations will be LPS controlled from the LCC. The use of fiber optic lines instead of copper wire to control motors and other transmitted/received functions should be considered a viable application in the design of the control portion of this system. Fiber optics would provide better operational performance by reducing impedance losses associated with copper wires. Additional studies should be performed to determine operational acceptance, reliability, and compatibility of fiber optics used in this system.

As additional studies progress into more detail, the design concept may vary and other concepts may be considered.

VOLUME III

SECTION 6

LRB MANPOWER

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LRB MANPOWER

The objective of this study is to determine the manpower requirements for replacing the SRB with an LRB based on a plan that begins with designing the facilities and ends in an operational STS launch capability of 14 vehicles per year. The category and number of all personnel required is included. Also program life cycle with manpower is plotted against the plan (15 years). As closely as possible, a direct comparison will be made between SRB and LRB manpower requirements.

Manpower requirements for the LRB program are projected for a phased implementation consisting of two 10-year overlapping periods spanning 16 years and beginning in 1990. The initial period is the activation phase which includes the following:

- Design Construction and/or Modification of Facilities
- Pathfinder Activities
- Introduction of LRBs into the Launch Process (ILC/IOC)
- Build up to a launch rate of 14 LRBs/Year
- Phase-out of SRB Launches

The second period is the operational phase which begins in 1996 with ILC and encompasses a fully operational 14 launches a year for the last 5 and 1/2 years. A total of 122 sets of LRBs will be launched during the operation era. The time interval where the activation and operational phase overlap is referred to as the transitional portion of the program.

The transition phase represents the maximum stress on NASA personnel. During this period they must cope with maintaining a sustained SRB launch rate of 14 per year, as well as becoming the coordinating interface for all the activities associated with the introduction of the LRBs. There is a high risk probability that the sustained SRB launch rate cannot be maintained, because of the magnitude of the task, and the normal launch activity.

SRB processing historical data is used as a baseline for cost and manpower requirements. Mature cost data is available for SRBs based on fourteen (14) prior flows recorded in the WBS/PWO

reporting systems. The SRB baseline manifest in ARTEMIS is used to develop LRB facilities and cost impacts so that comparisons can be made.

Even though proposals have been made for both a recoverable and a non-recoverable LRB, all manpower and cost structures are for a non-recoverable booster. In addition, the baseline data is for a pump-fed LOX/RP-1 booster. Other configurations will be addressed where there is an impact.

Manpower estimates are based initially on the concept that technicians will be stationized and do not move with the booster during the flow process. The initial staffing would not have to be as high as the fully operational staffing because of the low launch rate. There would be a ramp up over five years beginning with the transition phase. Thus far the discussion has centered on the required number of hands-on technicians required to support the booster flow.

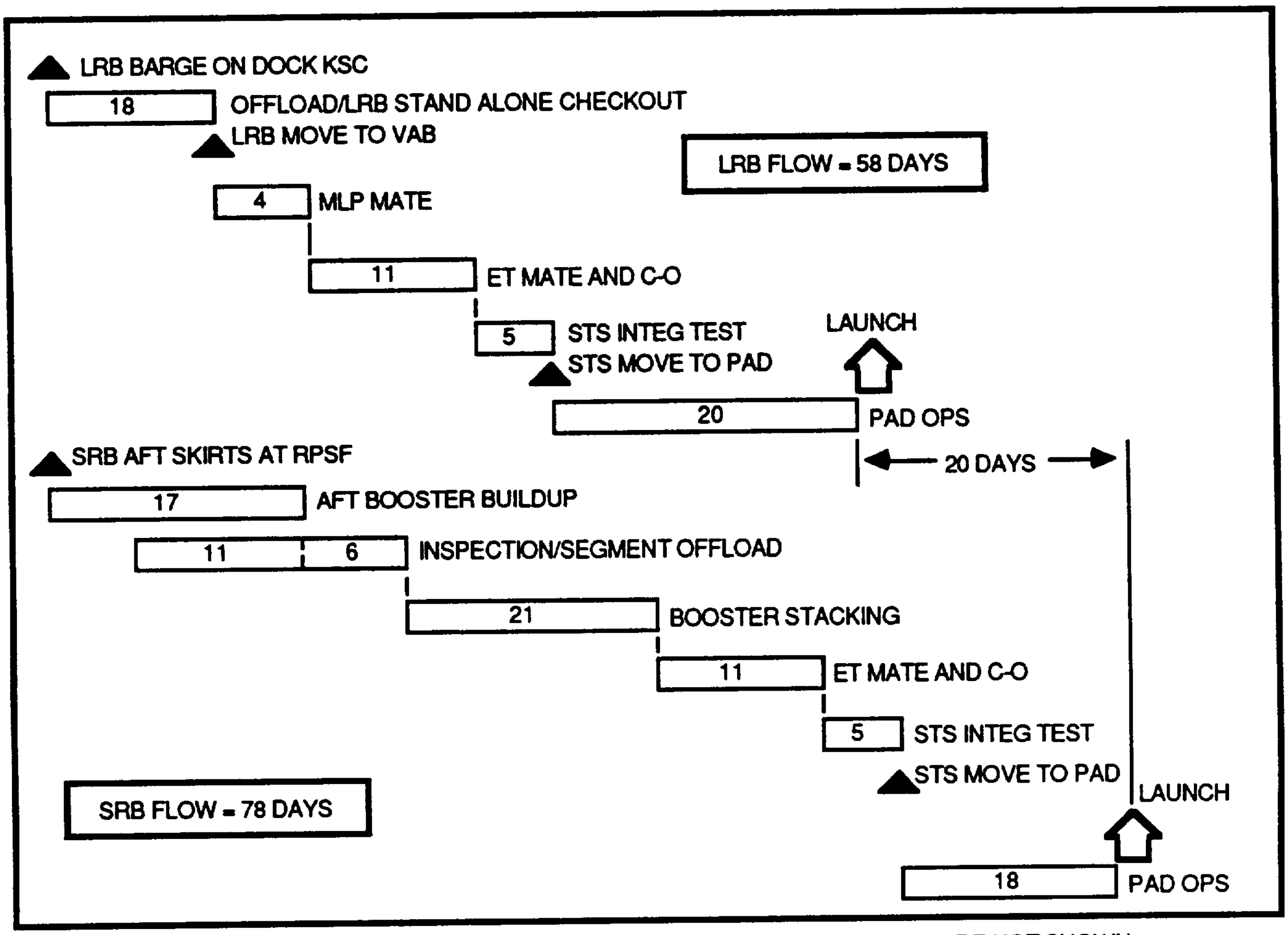
The manpower requirements are based only on scheduled routine tasks. There is no allocation for requirements generated by non-routine work. Best estimates based on other LRB/ET technology place this at 20% of schedule tasks.

Another assumption inherent to the study is that an A&E firm would handle design and a contractor construction, including modifications to existing facilities and support equipment.

An activation management team would be required to manage the program to minimize the impact on the present SPC team and the current launch schedule. In addition, there would have to be an increase to the existing support function to oversee and coordinate the design/construction phase of facilities and support equipment.

6.1 MANPOWER (CRITICAL SKILLS)

The manpower requirements definition began with an analysis of the hands-on technician and associated support staff required for SRB processing using 1985 WBS data. Fourteen flows representing a relatively stable period of work history were selected as a base line, during a time when the launch rate had reached 10 per year. This is a good approximation of a rate of 14 per year as projected for a fully operational LRB system. The time in each facility adds up to a total processing time of 58 days as shown in Figure 6.1-1. The critical path driver is MLP/VAB/Pad availability. Time at the Horizontal Processing Facility was maximized to allow smoothing of high man-



NOTE: SRB RETRIEVAL, DISASSEMBLY, REFURBISHMENT AND REMANUFACTURING ARE NOT SHOWN.

Figure 6.1-1. Generic LRB/SRB Process Flow Comparison.

power peaks but was : nited to 18 days by the maximum flow rate of 14 per year. The original LRB AF EMIS manning projections were based on a study flow with perfect leveling. Once the require number of hands-on technicians was established, based on the assumption that the SPC contract would process the LRB, the current ratios of support to technician that exists today in SPC w e applied to establish support requirements (see Figure 6.1-2).

Since there is a funda ental difference between an LRB and SRB, some changes in critical skills ratios are required to commodate these differences. Primarily these are in the areas of engine, electrical, and fluids :rvicing. Since the projection used for SPC LRB processing more nearly reflects the level of t hnical complexity for the Orbiter, the ratios of support were adjusted to reflect the middle gro d technical complexity of the LRB.

One of the areas wher the booster configuration would be an impact is in skill mixes. This will be address in Section 6.3

The number of techni ans and support personnel required for ILC would not be as large as that required for IOC. A : ialler number (50%) would be sufficient for the first year. This is possible because the processin time has been increased to accommodate the start up learning curves and the initially lower lau h rate.

The original ARTEM ; program used to project manpower and manloading assumed a 51 day flow with the manpo :r perfectly leveled. The manpower count for support was ratioed to the technicians required t this flow. A total of 64 technicians were needed using this scenario. A peak loading chart va es considerably (265 versus 64), because it looks at critical path management and does not a :mpt to average or smooth manhours. An alternate attempt to level manpower by movin; ill tasks to latest start/latest finish made the situation even worse (335). These ratios reflect th /ariances caused by the different assumptions in manpower utilization.

The same flow "51 d s" was examined by relating the manpower to facility with the personnel stationized. The ART MIS CPM was used to establish work sequence and timing.

A detailed presentati of the 51 day leveled projection, the peak loading projection, and the stationized approach i included in subsection 6.1.1.

The next area of criti l skills deals with the requirement for an activation management team to

SKILL MIX	RATIO	MH	LOADED RATE	COST	MH % OF TOTAL	COST % OF TOTAL
TECHNICIANS	1.0	26,110	$ 17.72	$ 462,669	12.38%	11.7%
PROCESSING		11,066				
VAB		5,336				
PAD		9,708				
ENGRG	0.89	23,238	$ 20.55	$ 479,390	11.0%	12.2
FAC & GND	1.14	29,765	17.20	511,958	14.1	13.0
LOGISTICS	0.53	13,839	16.19	224,053	6.6	5.7
QUALITY	0.38	9,921	18.29	181,455	4.7	4.6
SAFETY	0.08	2,088	18.29	38,190	1.0	0.97
OP & C	0.22	5,744	17.88	102,203	2.7	2.6
OVERHEAD	0.42	10,967	19.30	211,663	5.2	5.4
GTSI (LPS)	0.71	18,538	19.75	366,126	8.8	9.3
SUBTOTAL		140,300		$2,578,207		
BASE SUPPORT	1.22	32,090	$ 16.00	513,440	15.2	13.0
NASA CS	1.47	38,508	$ 22.00	847,170	18.3	21.5
TOTALS		210,898		$3,938,823	100%	100%

COMMENTS AND ASSUMPTIONS

1. LRB MHRS AND COST ARE BASED ON MULTIFLOW ENVIRONMENT (BASELINE + 30%)
2. MHRS AND COST FOR PROCESSING LRB'S FROM RECEIPT THRU LAUNCH
3. ALL SKILL MIXES ARE RATIOED TO MANHOURS
4. MHRS AND COST ARE BASED ON THE LRB PROCESSING FLOW
5. EG&G BASE SUPPORT ASSUMES 20% SUPPORT CARGO AND 80% SUPPORTS SHUTTLE ELEMENT PROCESSING
6. THE NASA/KSC CIVIL SERVICE VALUES HAVE THE SAME ASSUMPTIONS AS THE EG&G BASE SUPPORT ASSUMPTION IN ITEM #5
7. A NON-RECOVERABLE LRB IS ASSUMED IN THE ABOVE COST & MANHOURS

Figure 6.1-2. LRB Processing Manhours and Costs.

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startup and manage the program. This would be a multi-disciplinary group, composed of a j nt NASA/contractor community with both the management and technical skills needed to im- ment the LRB program, while minimizing the impact on the SRB program. See Volume III Sec- tion 1.3.1.5.

Other groups will be required during the activation phase. The design and construction of e facilities will be contracted out to A&E and construction firms. Within the exis ng SPC/NASA/BOC there is a need for persons to be involved in the design/construction/certific tion/activation of the facilities so that they can be qualified to operate the system for IOC. Th y would also be needed to apply "lessons learned" from prior operational experience to ie design/construction phase of the system. The skills and types will be further described and qua i- fied in Section 6.1.4.

Not all of this manpower would remain after the activation phase. The technicians and rela d support could become a part of the SPC contractor population.

6.1.1 Loaded Timelines

The baseline generic flow did not attempt to look at peak loading or time in facility flow n- straints. It used a fully averaged number based on the total flow length i.e.;

$$\frac{\text{Flow manhours}}{\text{Flow Time}} \quad \frac{26110}{51 \text{ days X } 8 \text{ hours}} = 64 \text{ technicians}$$

Reference Figure 6.1.1-1 through 5. (Note: Support functions were ratioed to the technician h d count based on the PWO system).

A second approach was made using manhours versus time in facility flow constraints ith fully averaged head count.

HPF

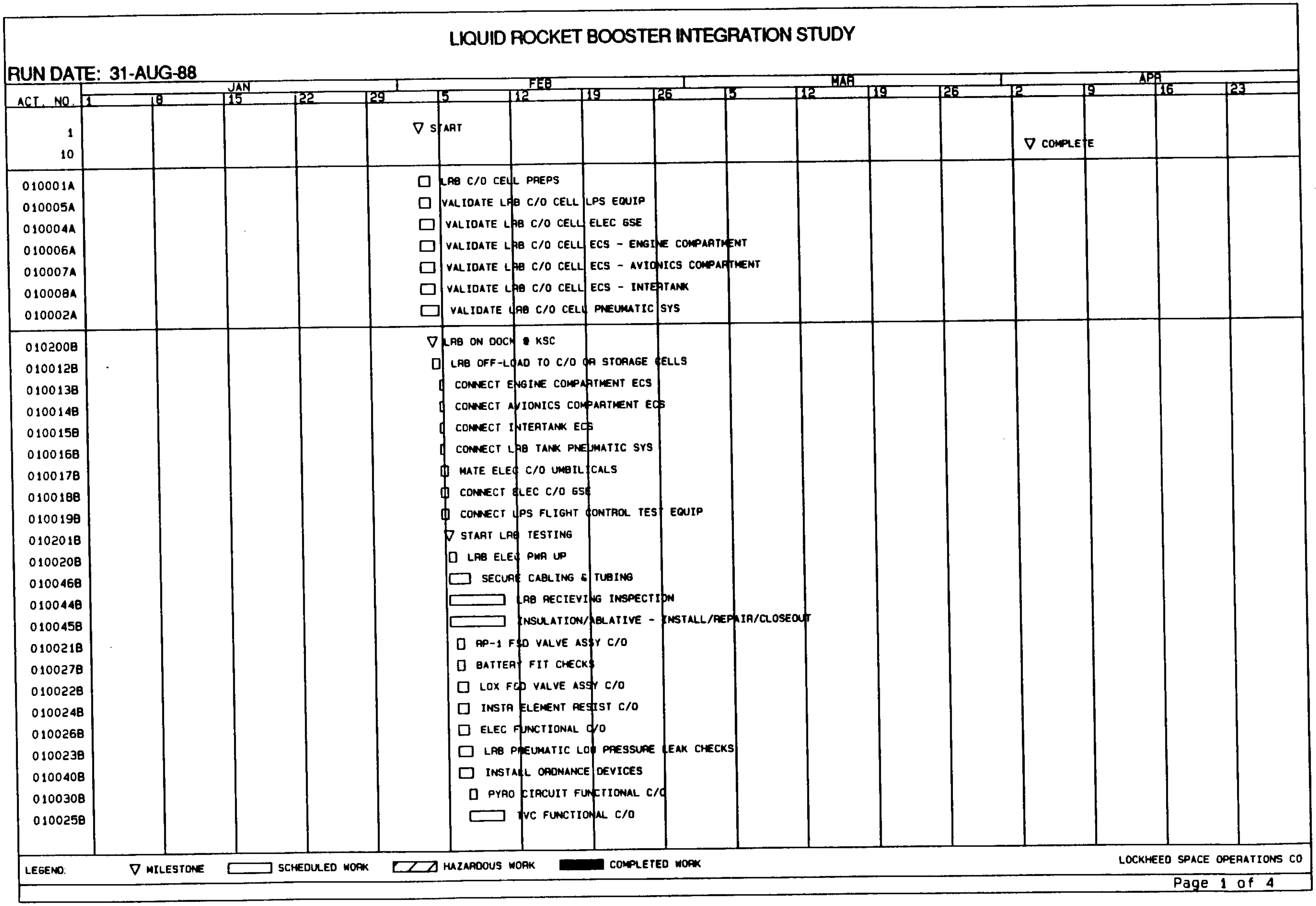
$$\frac{\text{Manhours}}{\text{Days Available}} \quad \frac{11{,}066}{18 \text{ X } 8 \text{ hours}} = 77 \text{ technicians}$$

SKILL MIX	RATIOS	MANHOURS	MANPOWER
TECHNICIANS	1.0	26,110	64
ENGINEERING	0.89	23,238	57
FAC & GND SUPPORT	1.14	29,765	73
LOGISTICS	0.53	13,839	34
QUALITY	0.38	9,921	24
SAFETY	0.08	2,088	5
PP&C	0.22	5,744	14
OVERHEAD	0.42	10,967	27
GRUMMAN	0.71	18,538	45
SUBTOTAL	5.37	140,210	343
BASE SUPPORT	1.60	32,090	77
NASA KSC	1.92	38,508	94
TOTALS	8.89	210,808	514

COMMENTS AND ASSUMPTIONS:

- MANPOWER BASED ON A MULTIFLOW ENVIRONMENT (BASELINE +30%)
- MANPOWER BASED ON A 51 WORKING DAY FLOW
- MANPOWER IS CALCULATED 8 HOURS A DAY TIMES 51 DAYS DIVIDED INTO MANHOURS

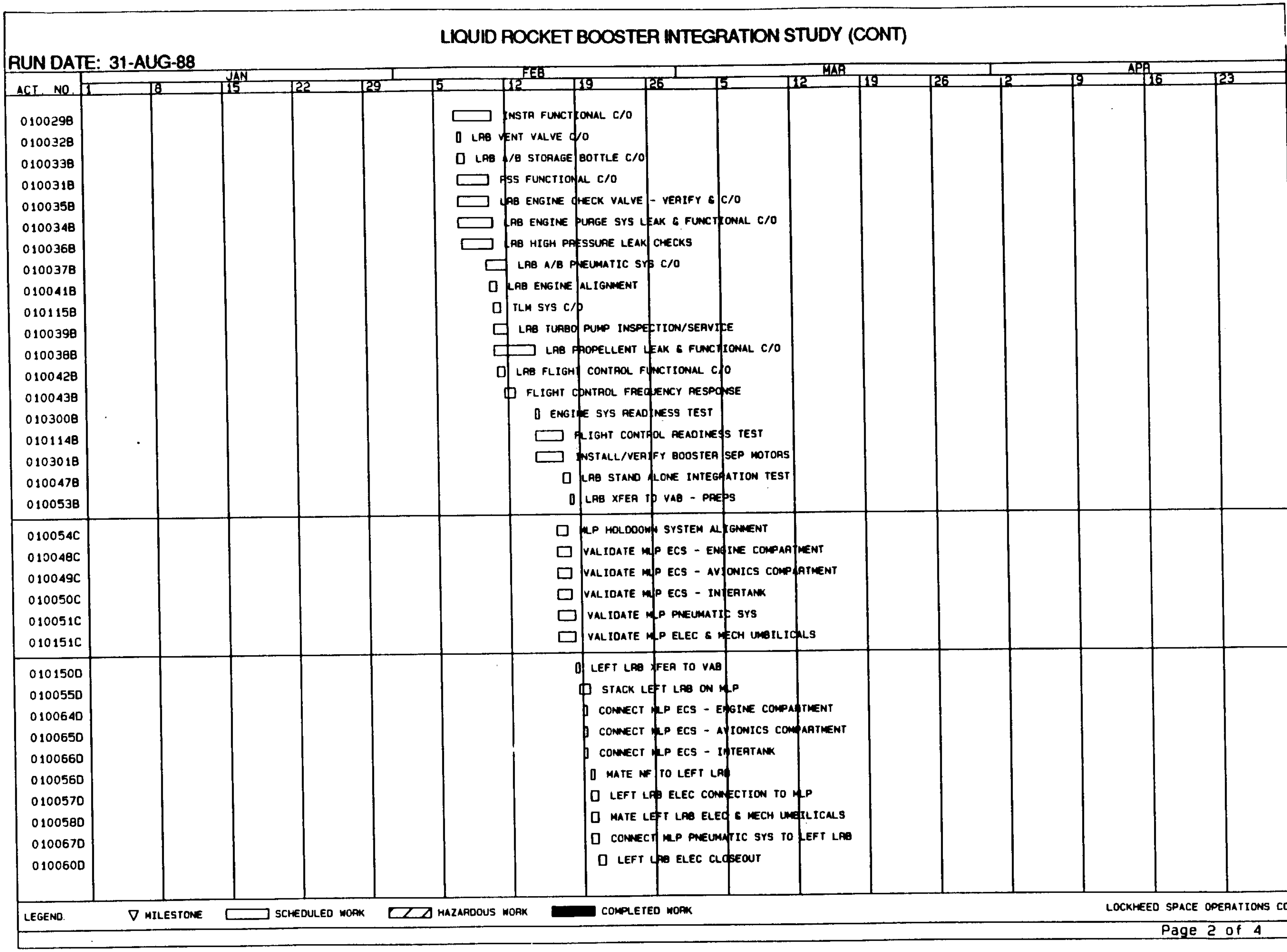
Figure 6.1.1-1. LRB Processing Manloading (51 Day Flow).



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Figure 6.1.1-2. Generic LRB Flow (Page 1 of 4).

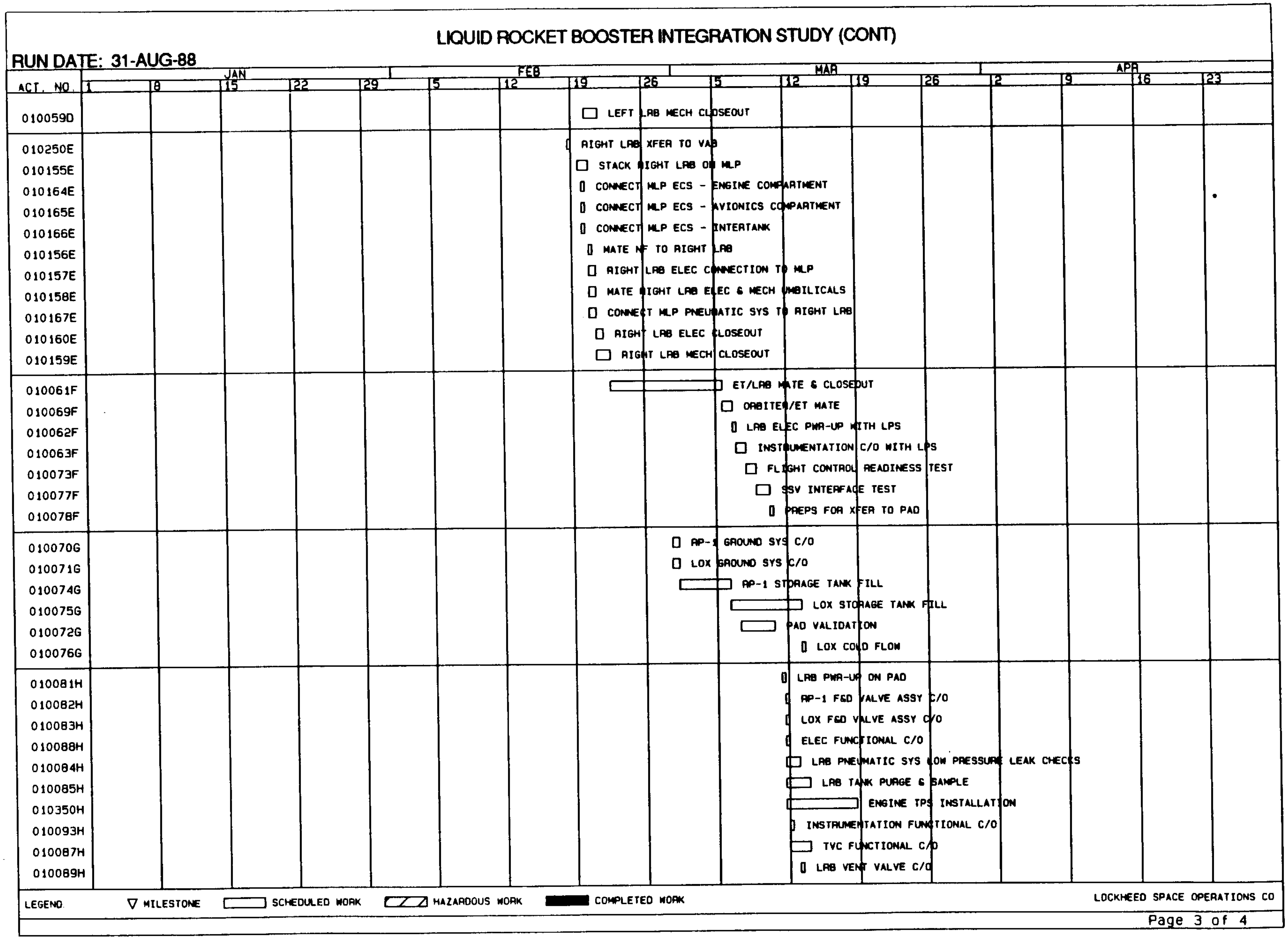
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Figure 6.1.1-3. Generic LRB Flow (Page 2 of 4).

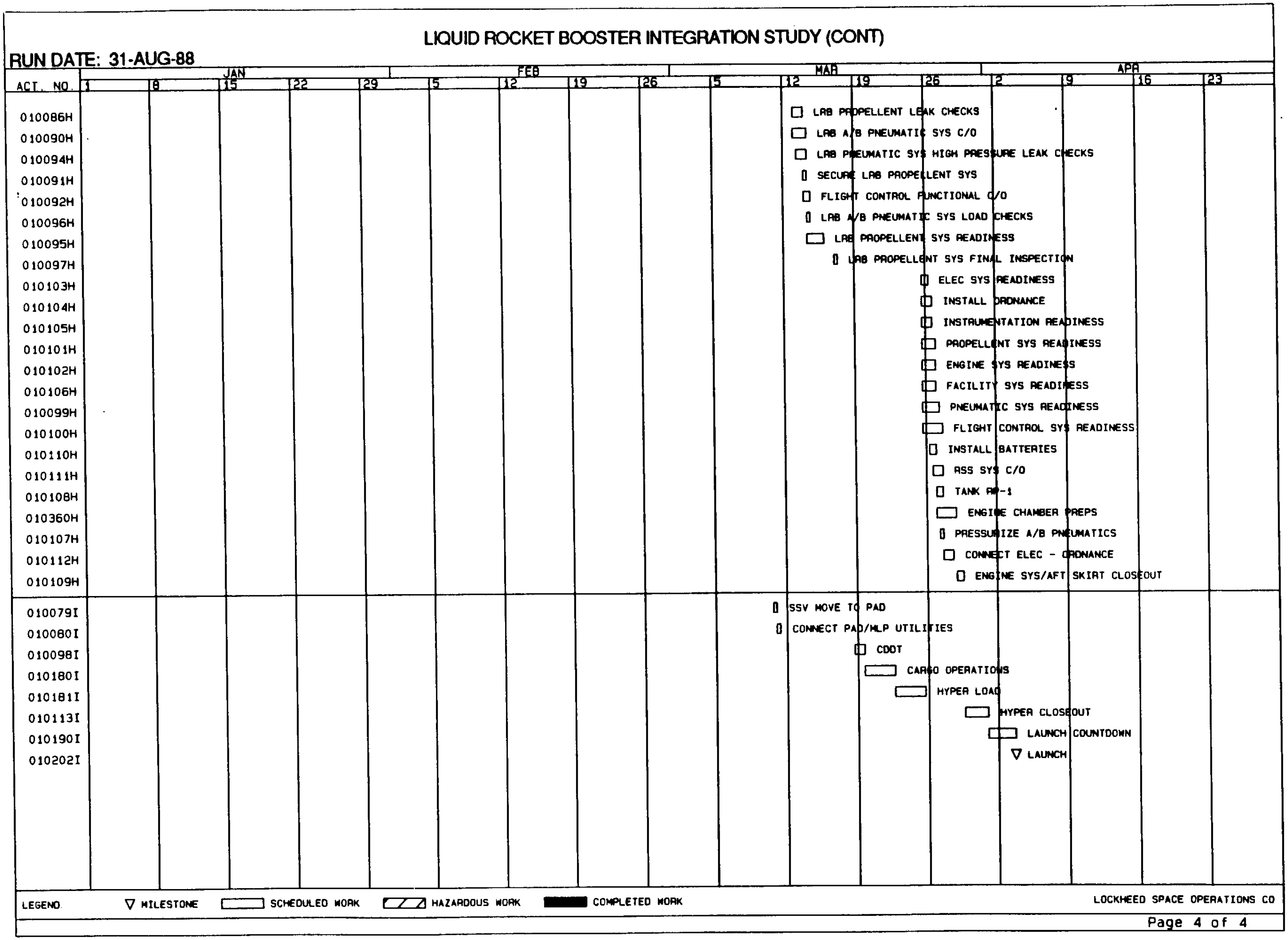
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Figure 6.1.1-4. Generic LRB Flow (Page 3 of 4).

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Figure 6.1.1-5. Generic LRB Flow (Page 4 of 4).

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VAB

Manhours	5336	= 33 technicians
Days Available	20 X 8	

PAD

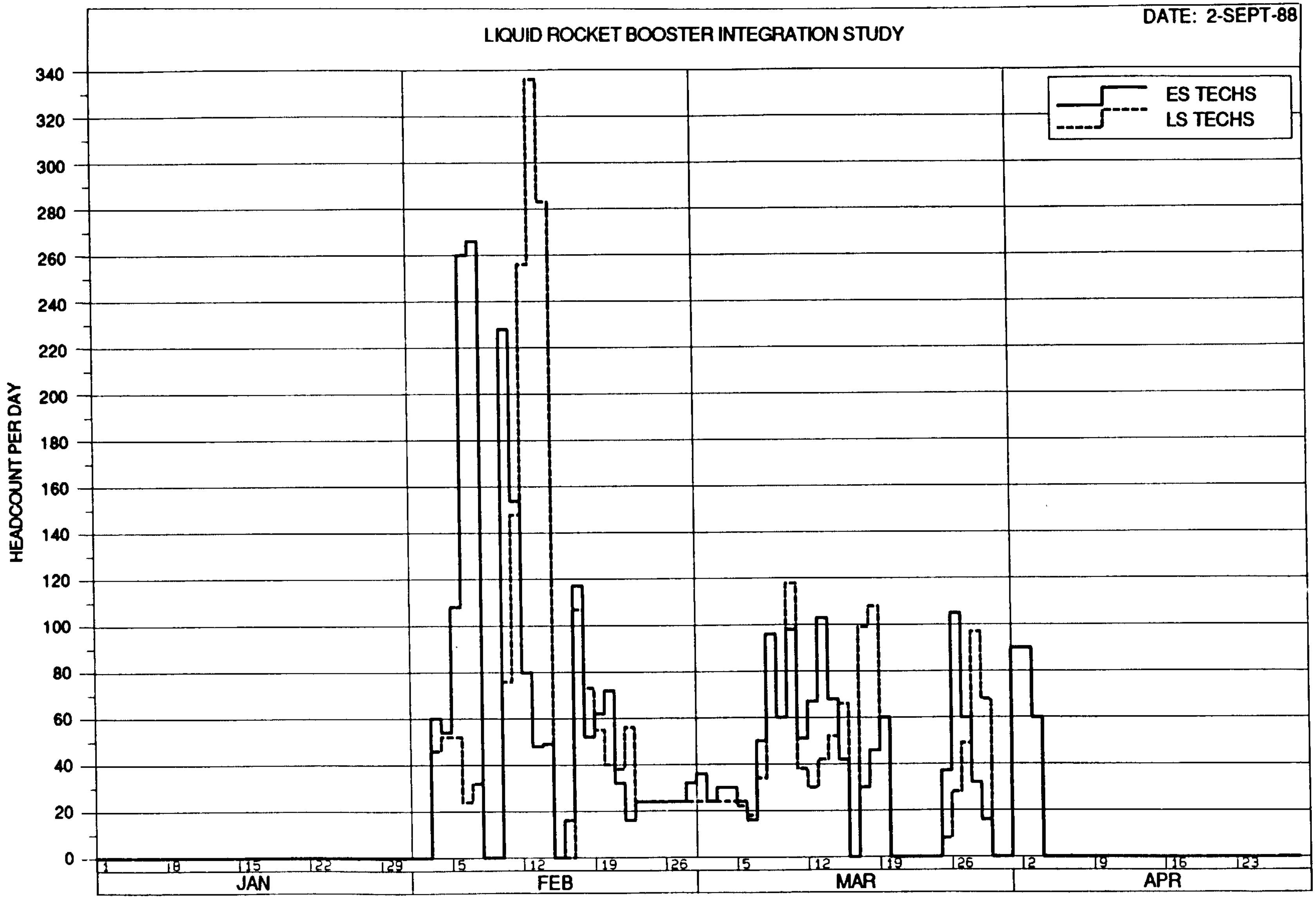
Manhours	9708	= 61 technicians
Days Available	20 X 8	

The peak loading projection based on critical path management without regard to "smoothing" manhours is illustrated in Figure 6.1.1-6.

Support hours were ratioed to the SRB manhours for NASA/BOC. LSOC support was ratioed to the original estimated manhours prior to the manloading exercised applied to the ARTEMIS CPM chart. This concept most closely approximated the present MT1 SRB staffing. Reference Figure 6.1.1-7.

A third approach was taken in which the ARTEMIS CPM flow prediction was manloaded to achieve minimum flow time in the HPF (11 days). There was no attempt to level or average manpower in any way. This resulted in a 51 day flow time. The peak loading was inefficient resulting in a requirement for 427 technicians to support the flow. Figures 6.1.1-8,9,10 show the peak head count required using this methodology. HPF = 260 VAB = 70 PAD = 107 Total = 437. These headcounts do not assume any support requirements.

It should be noted that in comparing the LRB to SRB technician count that the SRB technicians are non-stationized and that ET technicians are flowed to some SRB tasks. This helps to smooth out peak demands and results in a lower overall head count. It is probable that with a rate of 14 launches per year that the ability to flow technicians will be curtailed. Further work with ARTEMIS and other stochastic predictive techniques should be pursued to optimize manpower utilization. It should be noted that this is not an effort to predict what the staffing level by shift should be. That should be covered in a more detailed follow-on study once the LRB designs have been finalized and processing requirements have been more closely defined.



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Figure 6.1.1-6. Generic LRB Resources.

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SKILL MIX	RATIO	MANHOURS	MANPOWER
TECHNICIANS	1.00	26,110	171
ENGINEERING	0.32	23,238	55
FAC & GND SUPPT	0.41	29,765	70
LOGISTICS	0.193	13,839	33
QUALITY	0.14	9,921	24
SAFETY	0.03	2,088	5
PP & C	0.076	5,744	13
OVERHEAD	0.152	10,967	26
GRUMMAN	0.26	18,538	44
SUBTOTAL		140,210	441
BASE SUPPORT NASA/KSC	0.44 0.53	32,090 38,508	76 91
TOTAL	2.55	210,808	608

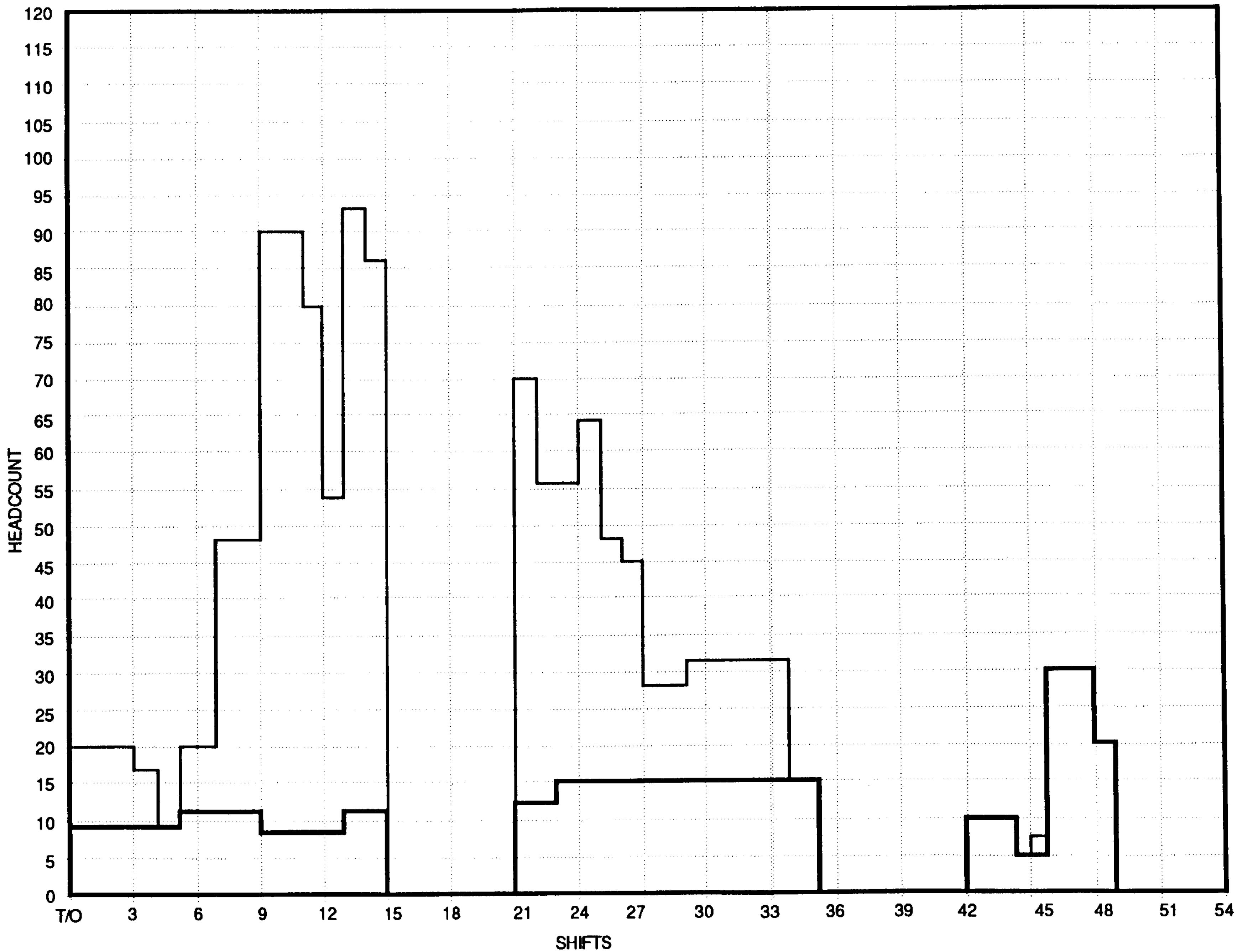
COMMENTS AND ASSUMPTIONS

1. MANPOWER BASED ON A MULTIFLOW ENVIRONMENT. (BASELINE + 30%)
2. MANPOWER BASED ON A 58 WORKING DAY FLOW.
3. MANPOWER IS CALCULATED 8 HOURS A DAY TIMES 58 DAYS AND DIVIDED INTO MANHOURS.

Figure 6.1.1-7. LRB Processing Manloading (58 Day Flow).

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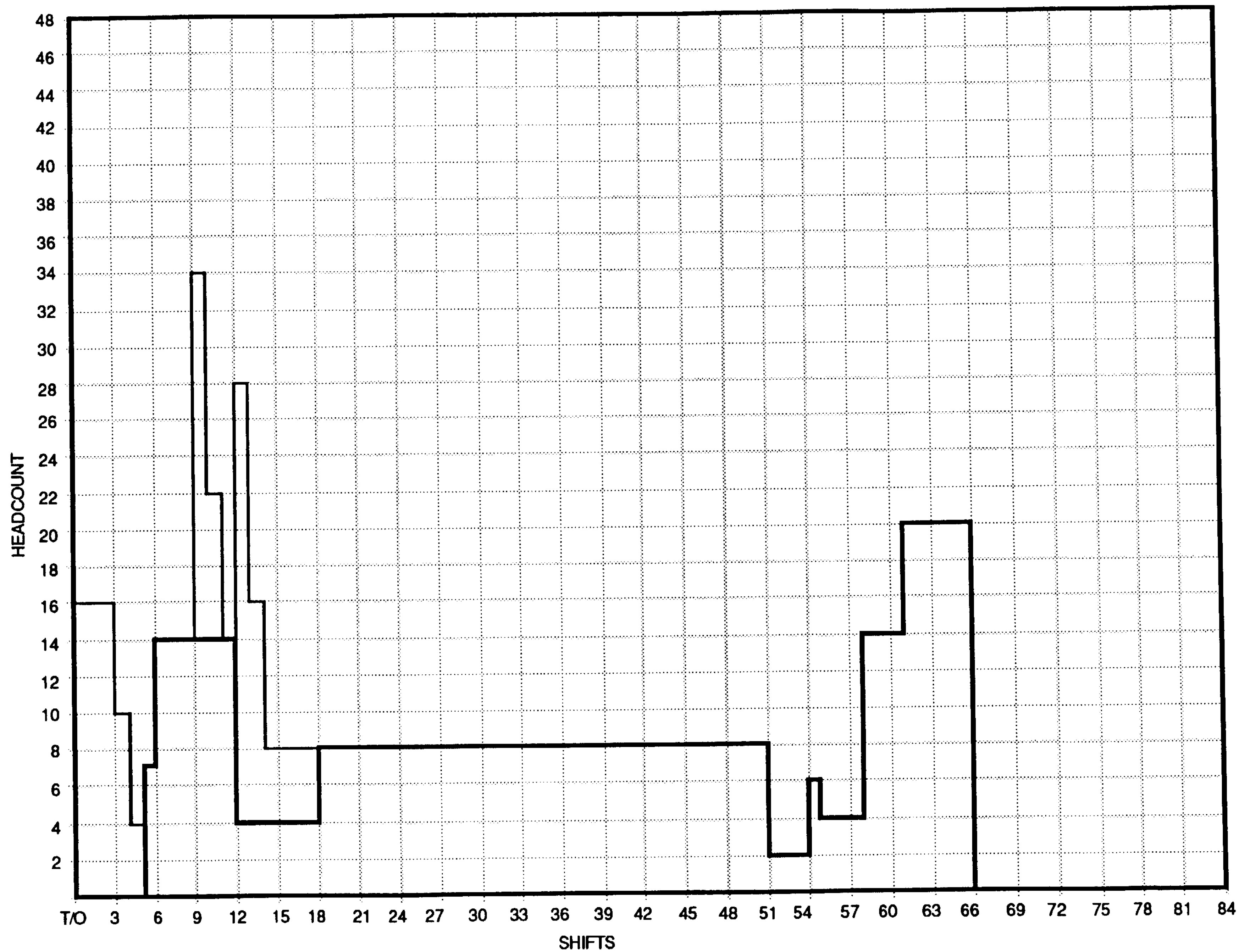
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Figure 6.1.1-8. HPF Manloaded Timelines.

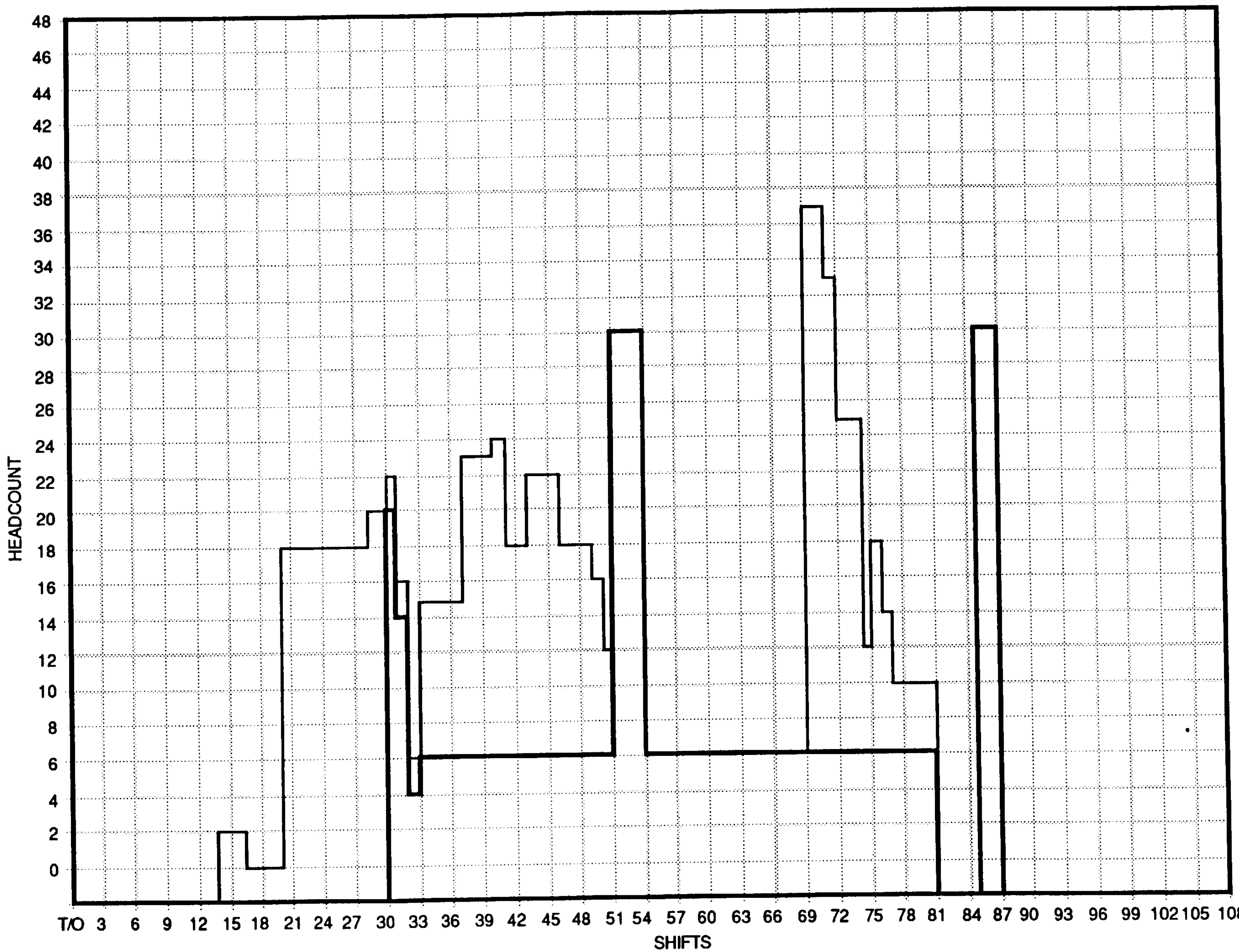
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Figure 6.1.1-9. VAB Manloaded Timelines.

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Figure 6.1.1-10. Pad Manloaded Timelines.

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6.1.2 Implementation Plan

Manpower levels will vary during the implementation plan based on activity and tasks to be accomplished over the 15 year period. A phased approach is being used for both the activation and operational aspects of the plan. Several different teams will be required during each phase of the operation. Reference Figures 6.1.2-1 and 6.1.2-2.

Starting with the Activation phase, the majority of manpower will be devoted to supporting the construction activity for the new MLP, modification of High Bay 4, the all new horizontal processing facility for the ET/LRB, modification of the first Pad and the modification of the LETF/LCC. The Activation Management Team (AMT) will be formed prior to the start of construction and manhours will ramp up sharply during the first four years. The AMT could be drawn from the current SPC contractor and NASA or hired from outside sources. There are considerable advantages to the internal approach - namely a good familiarity for the follow on transition and operational phase. Staffing levels for this phase peak at 363 persons in the 4th year.

During this activation phase there will also be a requirement for another support group. This team will have to come from the NASA/SPC contractor group, and will have a day-to-day interface activity to the A&E firms because of modifications to existing facilities. Their task will be to apply lessons learned from previous mods, familiarize themselves with changes to the facilities for future operations, assure that facilities remain inter-operable for SRB/LRBs, and assess the changes for risk analysis. The LPS system is especially critical from the risk standpoint because of the esoteric nature of a software driven test system.

The overlapping period in the plan is the transitional step. During this period of time a very complex mixed operation will be going on. In addition to construction of facilities, there will be the escalating LRB program and a declining SRB operation. This is probably the highest risk phase of the program due to the potential impact on operations (14 flows a year mixed SRB/LRB). The activation management team will begin merging into the operational team and some decline in SRB operations will cause a surplus of personnel. Layoffs will depend on how the activation management team was staffed. If it was chosen from the present NASA/SPC contractor group, a good orderly flow into LRB operation should be possible. If the AMT was chosen from outside sources, then a transitional turnover will be necessary. This has a high potential for operational problems.

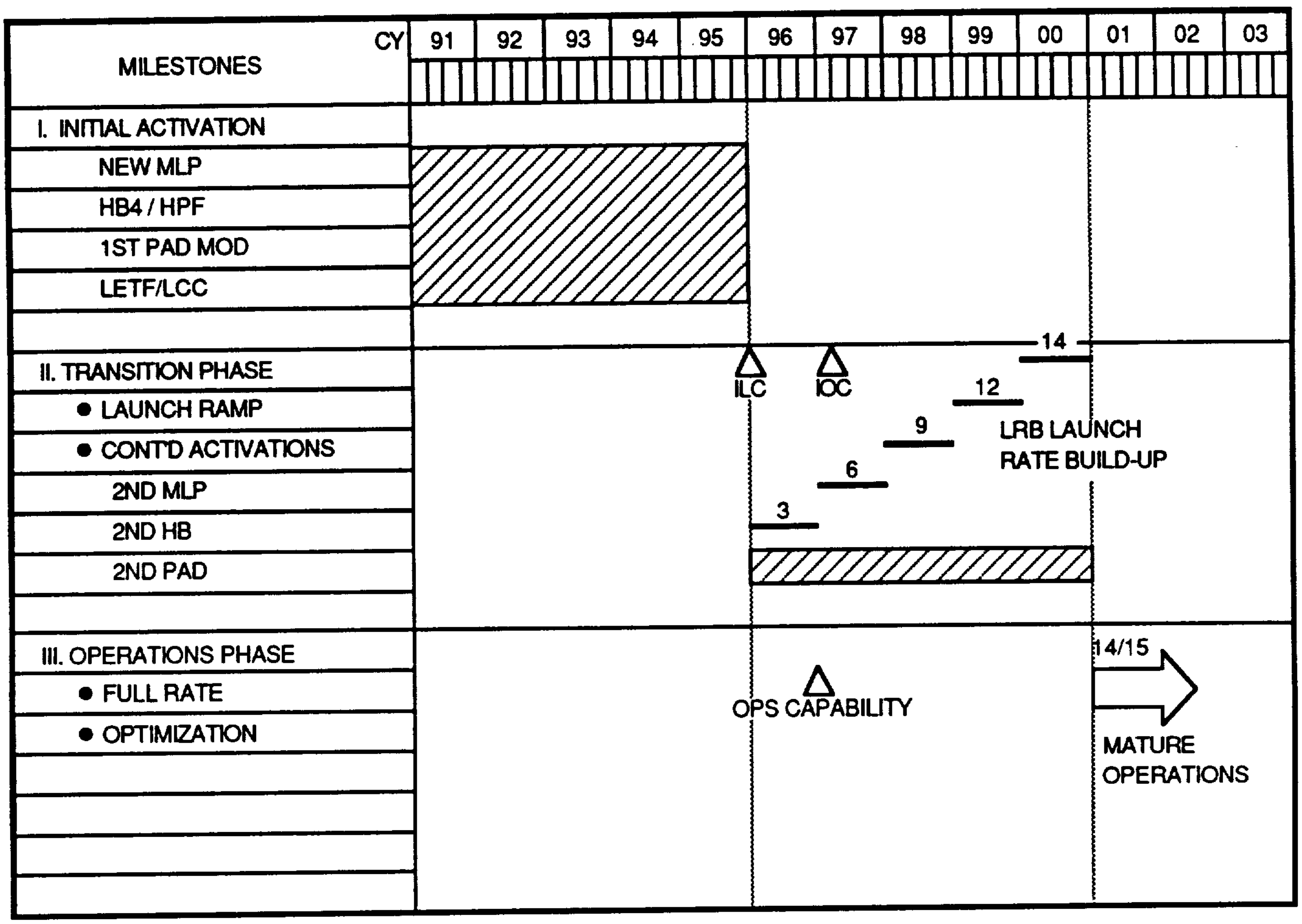


Figure 6.1.2-1. Phased Approach.

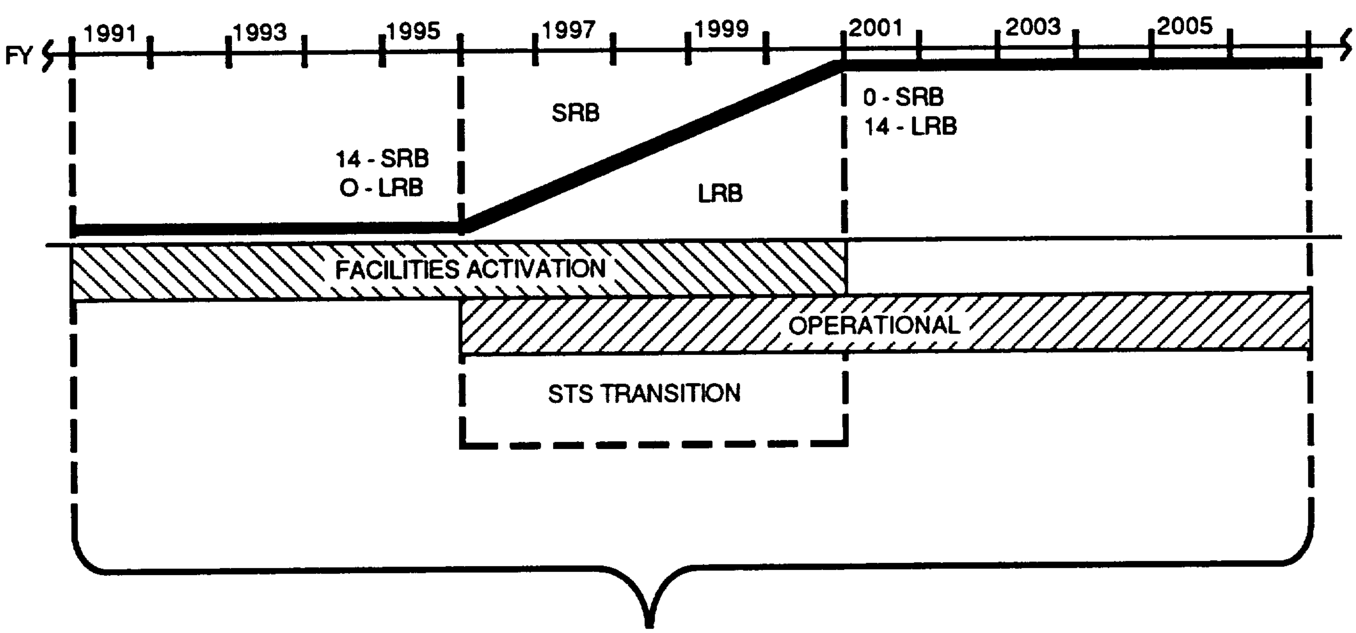


Figure 6.1.2-2. Overview of Launch Site Plan.

During the last part of the transitional period, SRB capability will be retained even though none are being launched. Two High Bays of the VAB will have been converted for LRB, the HPF is complete, both Pads are converted and LPS software is completed for the LRBs.

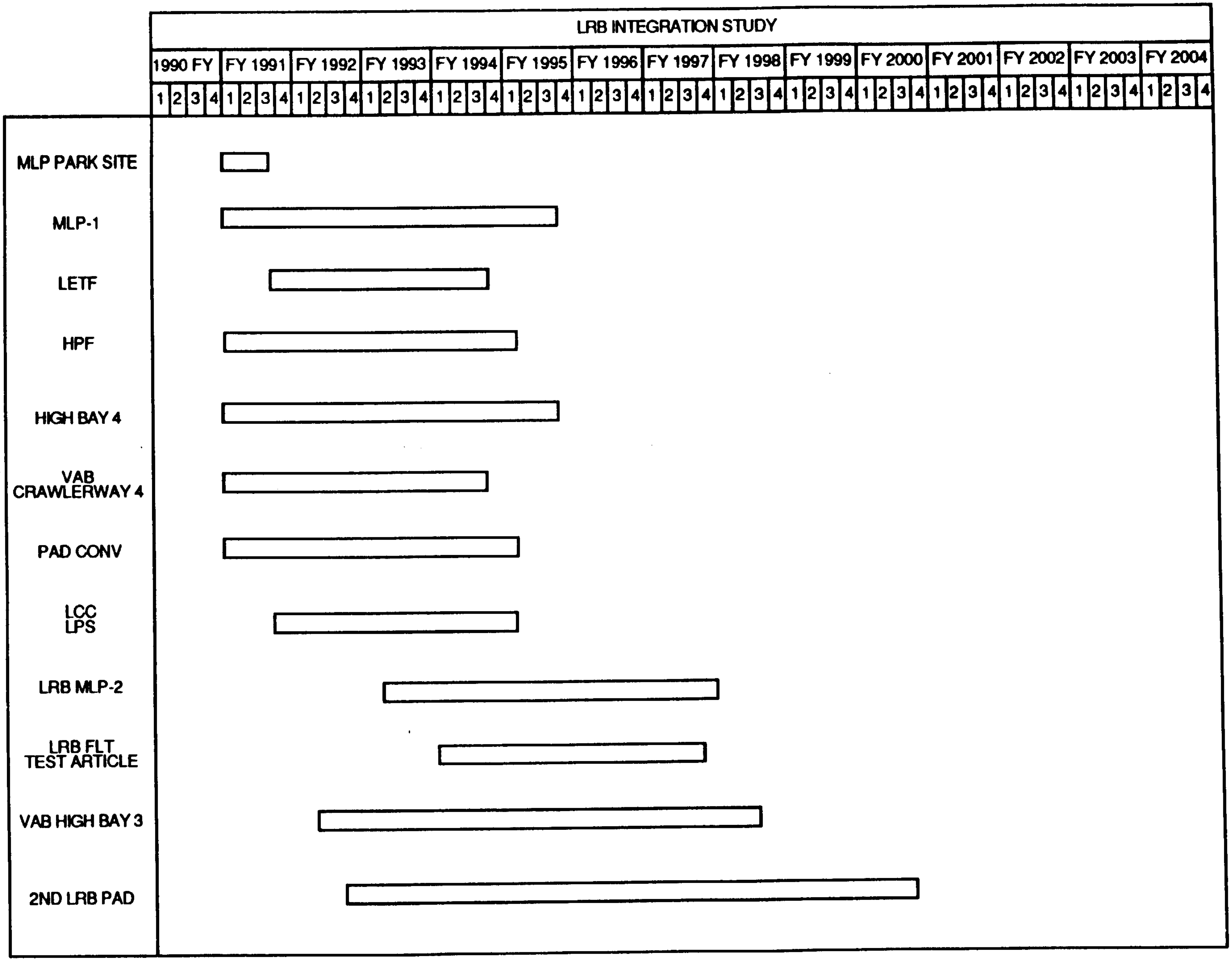
Beginning in FY 2001, the manpower requirements will have stabilized as shown in Figure 6.1.2-1 and a pure operational activity continues through 2006.

6.1.3 Design/Construction

During the design/construction phase of the plan (illustrated in Figure 6.1.3-1) the heaviest manpower will be provided by the A& E and construction contractors who have been chosen for the task. While a turn key operation would be desirable, that is not entirely possible. Several other teams will be very active during this phase. First of all a NASA or contractor team made up of Reliability, Quality, and Safety personnel will perform environmental and other impact studies for the new construction and modification of existing facilities. This team will function from 1990 until 1995. Next a NASA/or contractor team is needed to provide the following functions:

- Engineering direction/documents for Level II & III
- Change and approval loop
- Site (Field Engineering)
- Review and approve Interim OMIs/TPS Loop
- System Acceptance
- Walkdowns, test surveillance
- Schedule and work control
- Schedule Approvals
- Site Control for Staging
- Outage Loop
- Permit Loop
- Security Loop (Area Control)
- Change Control/ICD Approval
- Test Data & Approval from Level I & II
- Schedule Level III

These teams will be called the NASA Engineering Interface Team. These functions begin in 1990 and peak for five years - reference Figure 6.1.3-2.



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Figure 6.1.3-1. KSC Facility Activation Schedule.

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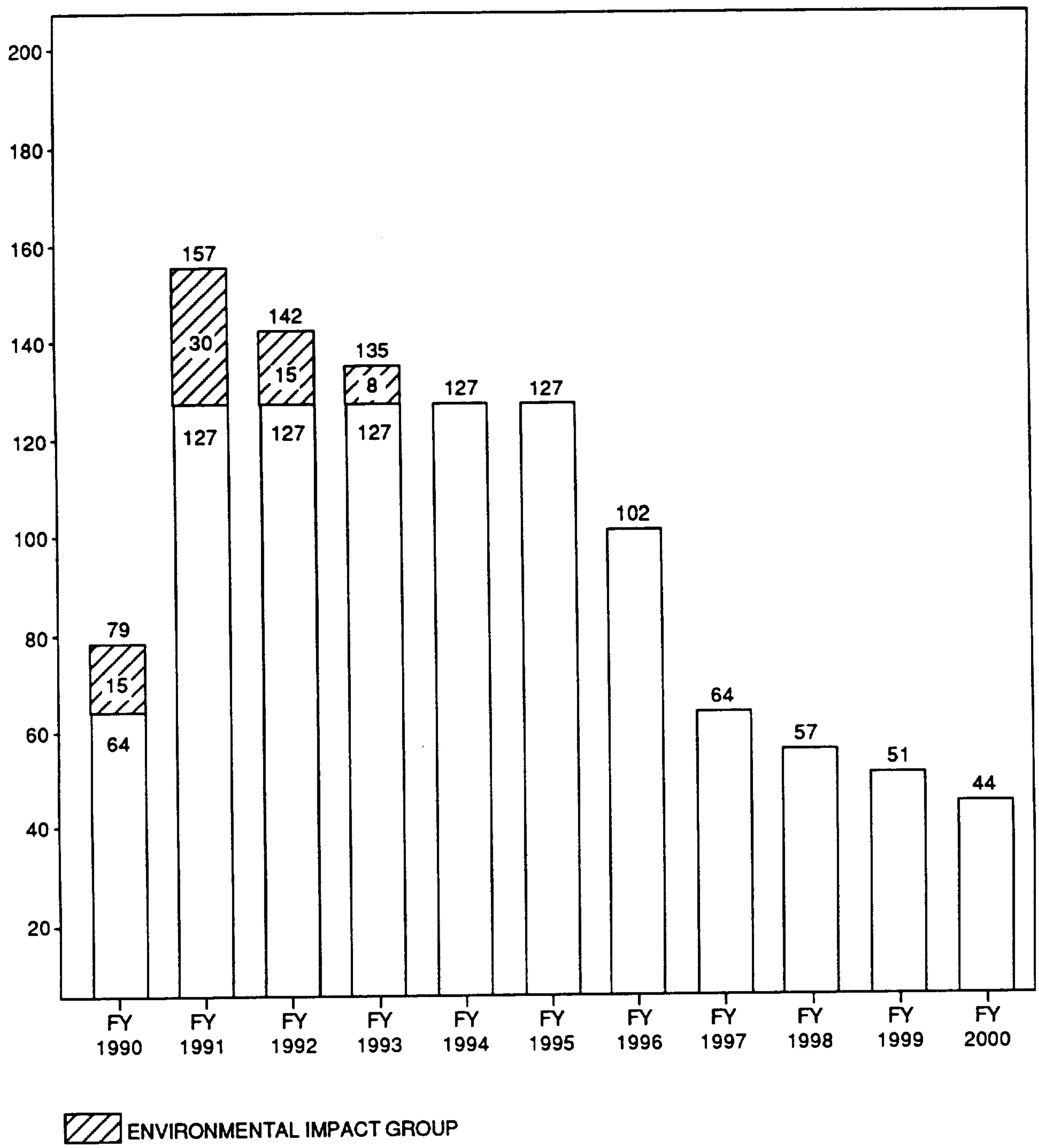


Figure 6.1.3-2. Manpower Requirements-NASA Engineering Interface.

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Another team, the Activation Management group will begin functioning during the design/construction phase. This team will be assigned the responsibility for bringing the program into the mainstream of the SPC flow with minimal impact on the normal flow rate. Their activity will begin slowly during the first two years but will ramp up sharply during the following three years. A lesser activity follows for the next five years.

In addition to the teams described above there is a requirement for a group made up of NASA Ops and O&M contractors to support the activation team. The following functions would be performed:

- Ops & Engineering OMDs
- Ops & Engineering Software
- Ops & Engineering Certifications
- Ops & Engineering ORI
- Ops & Engineering Pathfinder
- Ops & Engineering ORD Turnover/Acceptance
- Ops & Engineering CDR's
- Ops & Engineering Training

This team will be called the NASA Operations Interface Team. An LRB program office would need to be established, this team would begin functioning in 1991.

6.1.4 Activation

All of the teams put in place for the design/construction phase continue to function as facility modifications and new construction are completed and turned over to NASA and the SPC contractor for the early start-up program. The LRB hardware is on the dock, the LRB HPF, VAB HB-4, Pad B and LRB MLP have all been certified and accepted. A Pathfinder activity has begun, the LRB and ET have been processed through the HPF, and vehicle integration has occurred in the VAB. Manpower requirements have nearly peaked and ILC will be available early in the next year, reference Figures 6.1.2-2, 6.1.3.1, and 6.1.4-1 thru 6.1.4-3. This is a critical period for the Activation Management team because of the high levels of coordination required to accomplish an orderly and effective turn over of facilities. Also occurring in this phase will be the hiring, training and certification of a core cadre of technicians and support personnel necessary for Pathfinder/ILC.

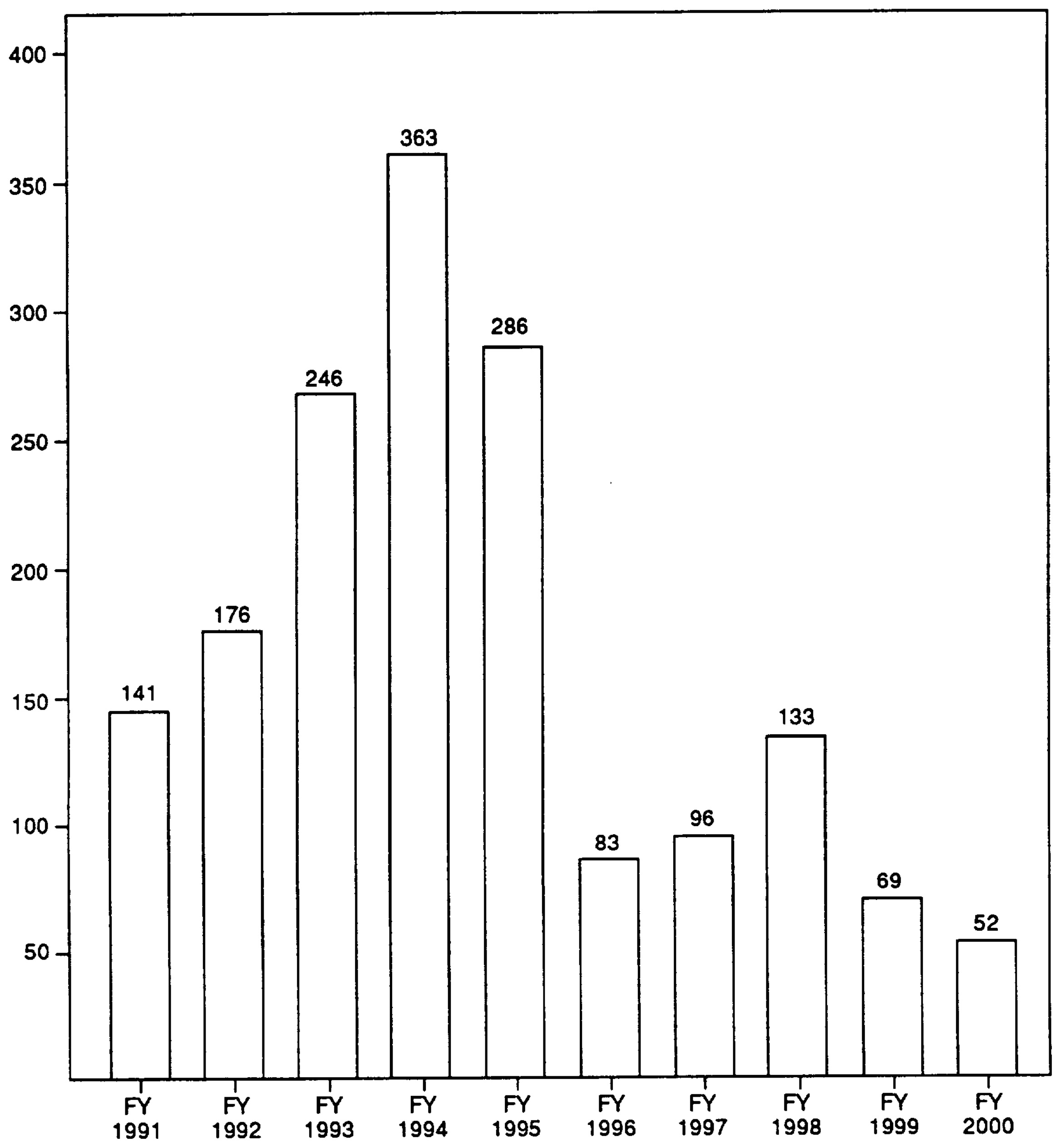


Figure 6.1.4-1. Manpower Requirements-
Activation Management Team.

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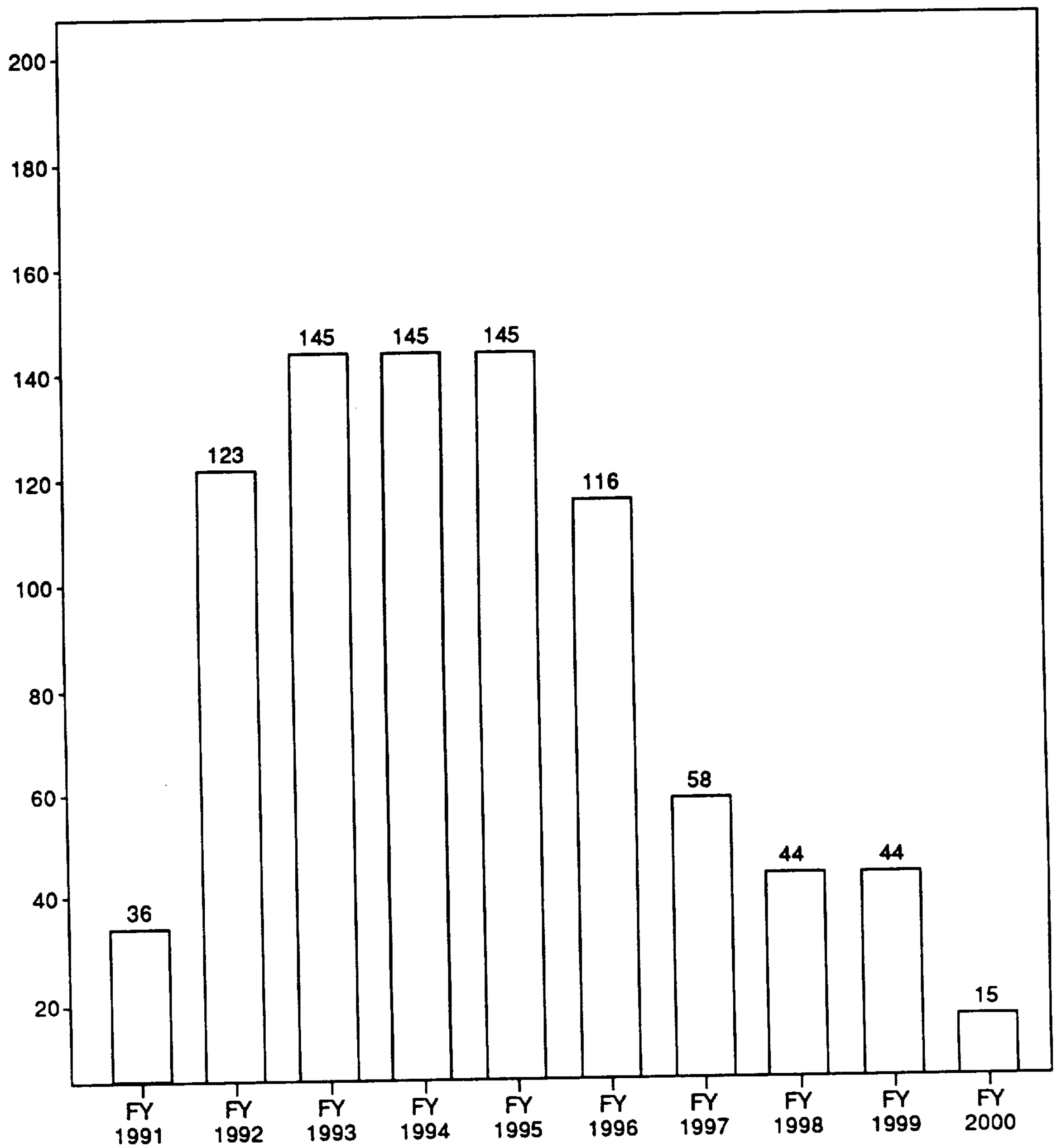
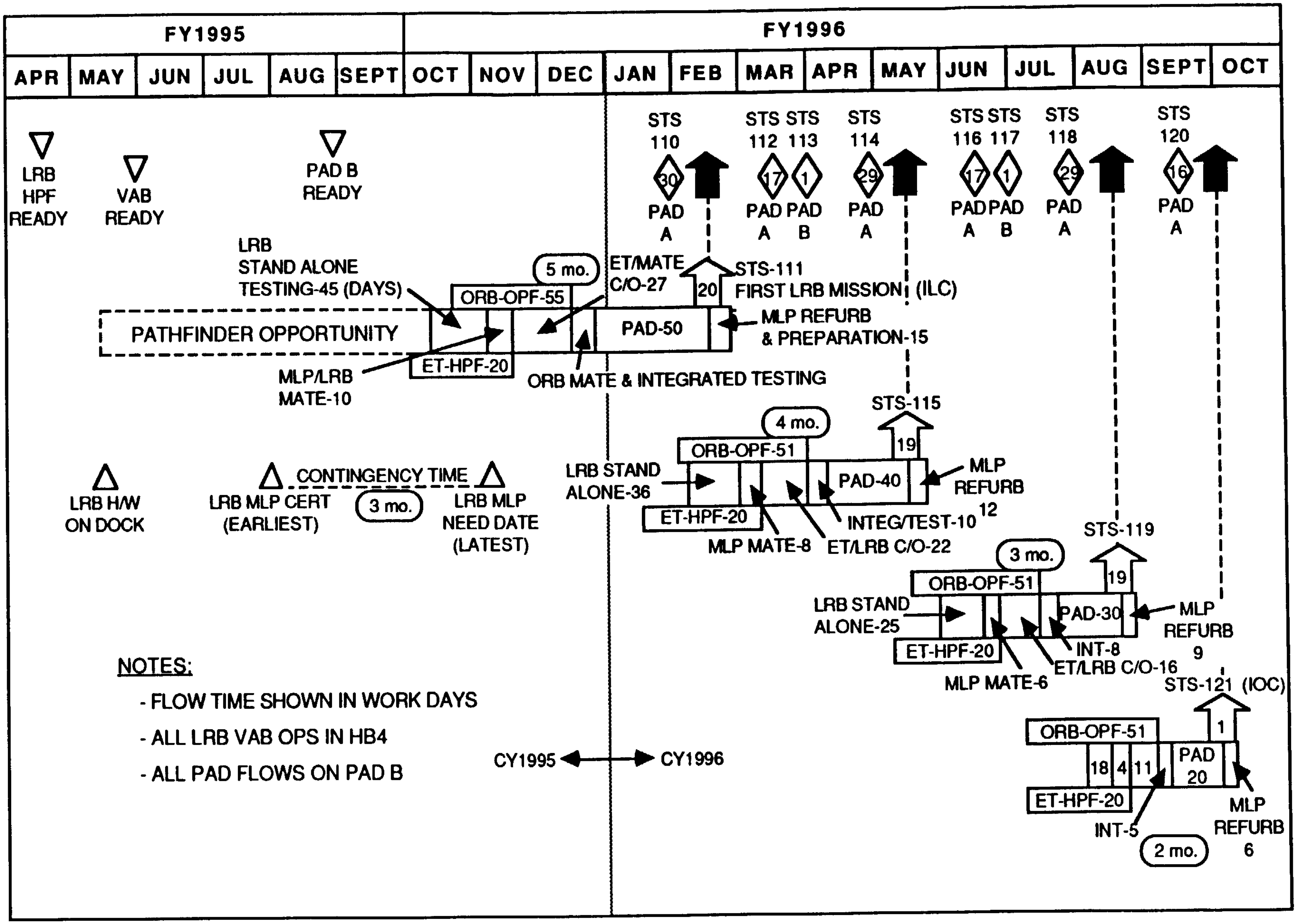


Figure 6.1.4-2. Manpower Requirements-NASA Operations Interface.

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Figure 6.1.4-3. LRB Processing/Launch Transition to I.O.C.

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6.1.5 Transition

The transition phase represents the ultimate stress on the launch system. Headcount peaks during this period of time due to the following activities:

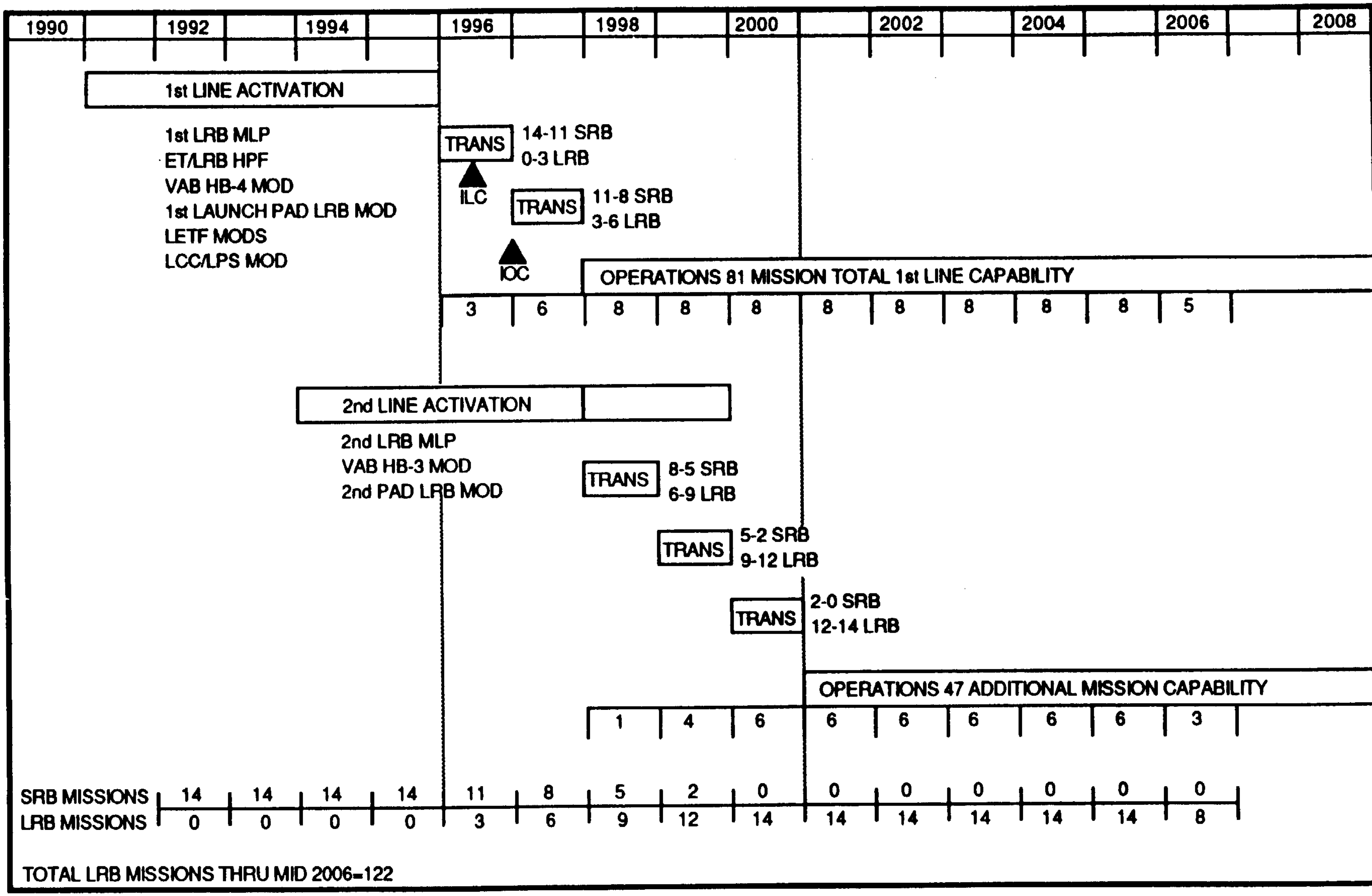
- ILC/IOC
- Completion of the second LRB MLP
- VAB HB-3 modifications
- Pad A LRB modifications
- The five year change over from SRB to LRB

Reference Figure 6.1.5-1

The LRB processing contractor (SPC) team will go from no launches per year to a sustained rate of 14 per year. Headcount will ramp up to full staffing by the year 1998 and will remain relatively constant for the remainder of the program NASA/BOC will be separated out from the SRB program and those SRB related support functions will see a declining headcount. The Activation Management team which peaked out in FY 94 will begin a declining headcount mode which will result in phase out by FY 2000. Some of this team will most likely be absorbed into the Processing/BOC/NASA team to take advantage of the experience gained during Activation/Transition.

The NASA Engineering Interface team will also go through a phasing out process during the transition era. The environmental impact team will have completed its work just prior to the start of transition. All other activities of the remaining team should be complete by FY 2000. As is true of the Activation Management Team, it is probably desirable that some part of the Management Support Team join the LRB processing team to reinforce the experience level in certain prime areas.

The NASA Operations Interface Team support to the Activation Management Team will likewise be in a declining mode during transition. It's primary support takes place during the FY 93 - 96 time span and then tapers off to nothing by FY 2001. Many of its activities during transition are in support of bringing the second line activation into fruition. A few members of this team would also be invaluable to the operation phase of the LRB program.



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Figure 6.1.5-1. KSC SRB to LRB Transition Plan

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6.1.6 Operational Phase

The operational phase represents the culmination of 10 years of intensive design, construction, activation and transition activities. With the SPC LRB team enriched by infusions from the other teams a full 14 launches of LRBs will be a reality. The challenge now begins on how to take advantage of other technology and process advancement that have been realized in Orbiter and ET processing. These are some of the factors:

- SPDMS increased capacity and capability
- Paperless OMD/work control system
- Reduced Orbiter processing times
- Maturity of Orbiter operating reliability
- Reduced LPS integrated testing requirements based on increased system reliability
- Maturity of LRB processes
- SDI/Space Station Launch requirements
- More effective automated Work Control and Planning

All of these factors will increase pressure on the LRB processing team to increase the flow rate, which infers that processing times will have to be reduced. Any hardware problems which could impact launches will require preplanned actions rather than crisis management. Pressure will also mount to reduce headcount required for the process to achieve operational economies. Even though Figure 6.1.6-1 shows a constant head count for 2001 - 2006, it is predictable that it should begin to decline by some reasonable factor. During this period, however wear and tear on the equipment and facilities will require an increase in maintenance/repair support.

This is also the period when decisions will have to be made about SRB facilities and capabilities. Either they go away or other programs keep them alive. These are decisions that must be made to determine if facilities dedicated to SRB could be converted to LRB should there be a requirement to increase the launch rate for LRBs. There could be a requirement for other programs to use the facilities.

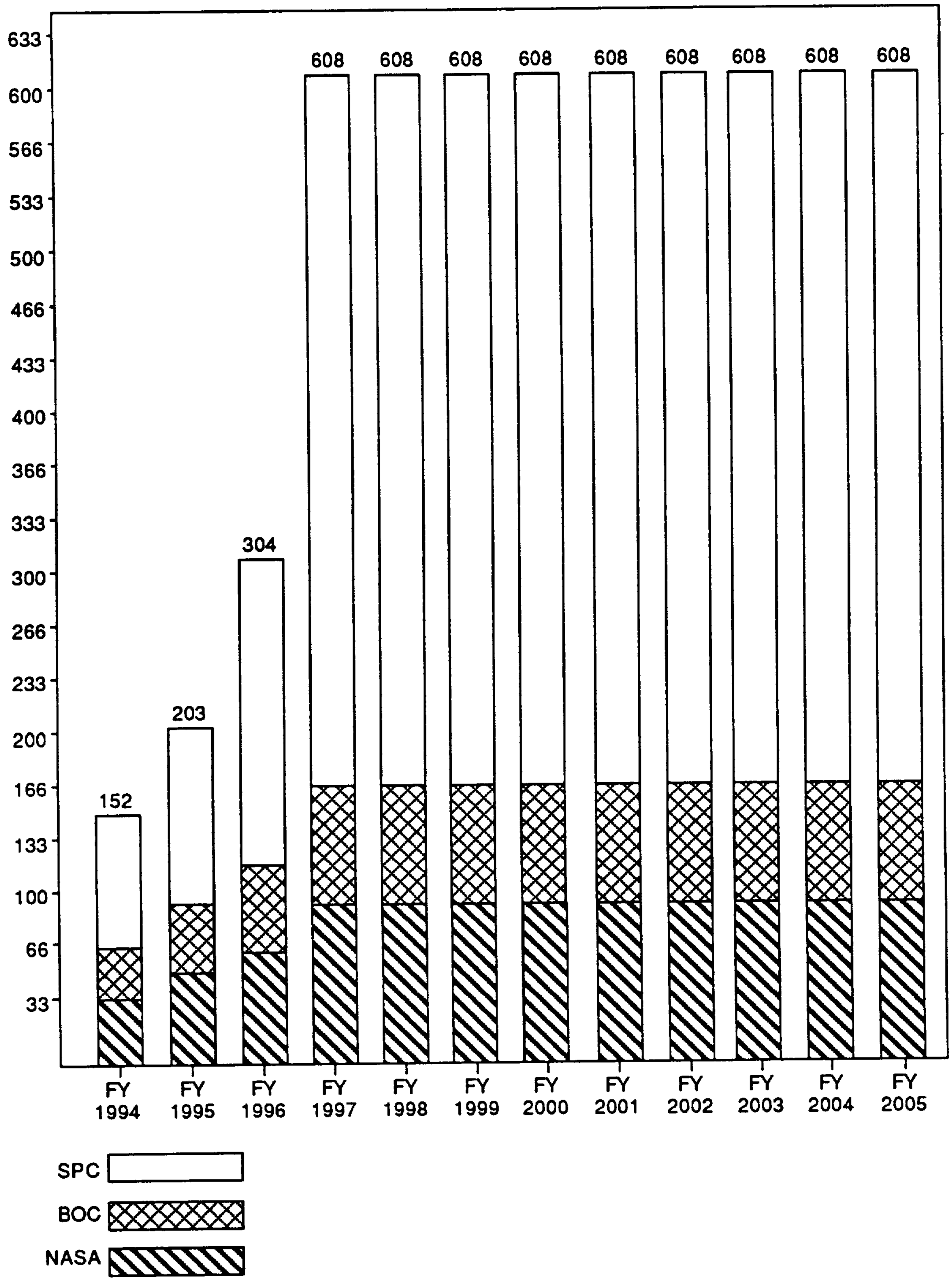


Figure 6.1.6-1. Manpower Requirements - LRB Processing.

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6.2 SHIFT WORK

The assumption has been made that shifts will vary by location; in some part driven by the critical path nature of the operation. Figure 6.2-1 illustrates the number of shifts and days worked at each location. The VAB is the only facility where three shifts - seven days a week is forecast from day one of the program. No attempt has been made to determine manning by shift. This is a very complex problem and will require a depth of knowledge of the technical content of the work documents before such details could be approached. Until the final design characteristics of the LRB have been determined such information is not available.

These shift and day requirements will also vary during the various phases of the plan. During the end of the Activation and Transition phase lower manpower levels will modulate these requirements. The experience gained toward the end of the Transition phase should stabilize the requirements so that they resemble those shown in Figure 6.2-1.

6.3 SKILL MIX

Figure 6.3-1 shows the skill relationships predicted for the LRB versus the SRB. The SRB is a known quantity based on experience gained in some 26 flows. The LRB skill mix was based on an examination of the predicted work tasks in the ARTEMIS projection used for the baseline. It is interesting to note that the electrical skill mix came out to be the same for both the SRB and LRB, even though the LRB uses electrical rather than hydraulic TVC and flight controls. This can be partially explained by the fact that MTI use electrical technicians to perform mechanical work for which they are qualified as well as electrical work. They have a fairly high degree of cross utilization in a one-way direction. The other area of question is the low ratio of engine technicians to mechanical/electrical. Especially in light of the fact that there are four engines per booster. In assessing the work tasks, any job that was related to TVC/flight controls/telemetry was assigned to the electrical skill group rather than engines. Secondly, any tasks related to plumbing attached to the engines was given to mechanical. If these assessments were reversed both mechanical and electrical skills would be lesser requirements and the percentage of engine skills would increase appreciably. The actual percentages will probably be somewhere in between. As has been noted in the Introduction section, no manhours are allocated for non-routine work generated by Problem Reports (PR's). These are estimated to be in the area of 20% of routine tasks. The largest portion of this would probably be generated by engine/engine LRU changes and TPS repair work.

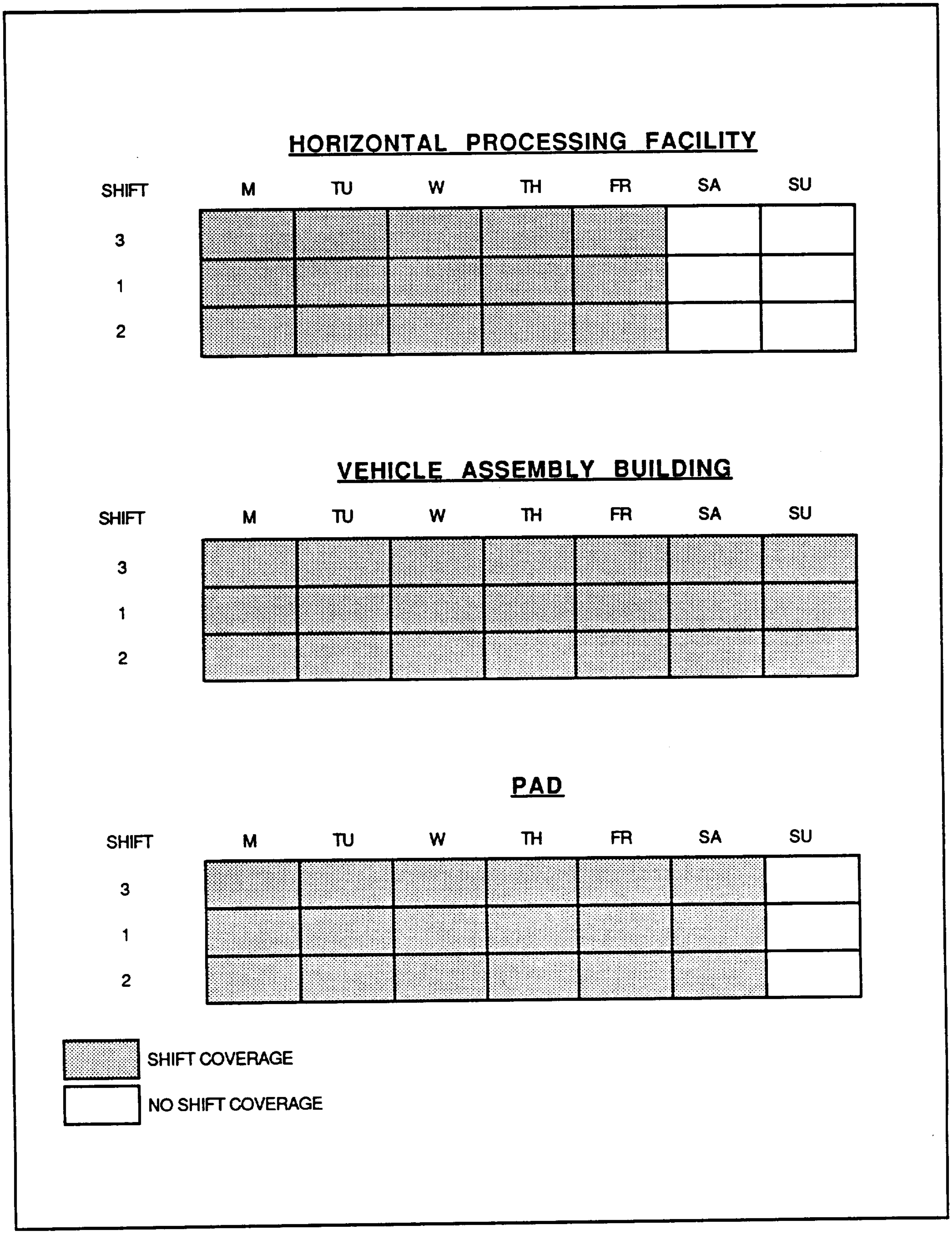


Figure 6.2-1. Shift Work

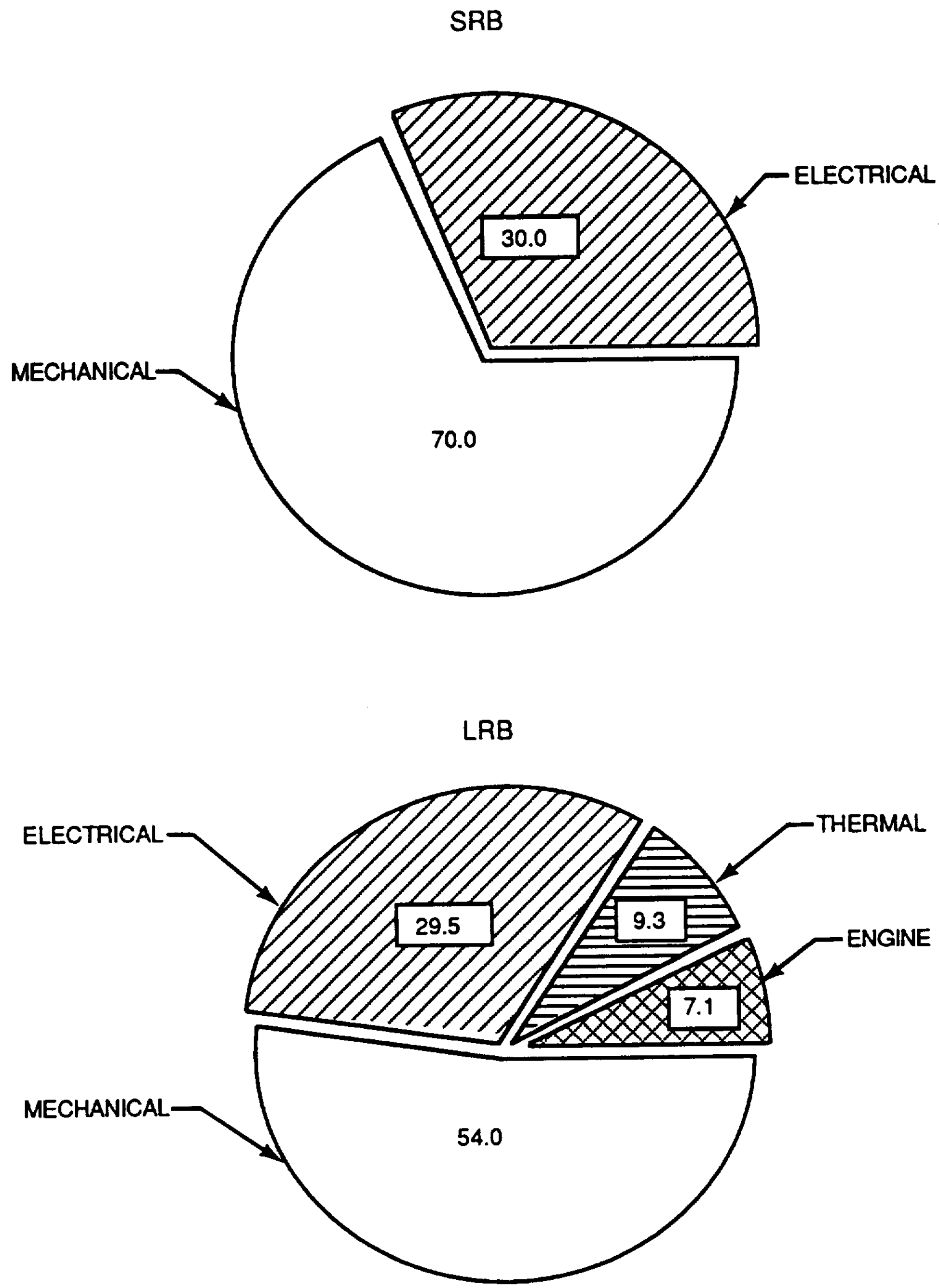


Figure 6.3-1. Technical Skill Mix

Several configurations of boosters have been proposed in this study, but thus far the pumped LOX/RP-1 engine has been used as the baseline for manpower estimates and skill mixes. The pump fed LOX/LH2 booster should be very similar to the LOX/RP-1 with respect to HFP man-hours and skill mixes, as well as the VAB. The main difference would be Pad servicing, with a possible longer fueling time since the RP-1 fueling would not be done during the countdown, but could be accomplished prior to the countdown in parallel with other tasks. The increase amount of hydrogen required for combined ET/SRB would increase fueling time.

The pressure fed LOX/RP-1 configuration presents a less complex engine but a more critical structure because of higher pressures and the potential for leaks. The headcount requirement is probably a " wash" in manhours with a shifting in skill mixes from engine to mechanical type technicians.

One of the study contractors on LRB engines has recommended a well equipped and sized engine shop with fairly large staffing to support the LRB operation. They have real time experience with the SSME engines which are comparable in size to the LRB engines. The facility would provide an excellent resource for KSC not only for LRBs but other proposed programs as well. However, not all of the burden for such a facility should be imposed on the LRB program. The estimates of facilities and manpower for the other phases of LRB processing have assumed a more conservative approach. They are based more on a "ship and shoot" concept, and a very "success oriented" flow processing. There does need to be some engine repair/change out capability to meet contingencies caused by unexpected problems found during flow processing. To not have this could impact LRB time in process and create critical path time constraints to launch capability. The quantities and skill mixes discussed here take a more conservative numbers approach. A better assessment will have to wait on final design and OMD information.

6.4 SUPPORT (BY PHASE)

Cumulative LRB manpower by phase is summarized in Figure 6.4-1. An examination by phase points out some important impacts to the program.

The Activation Phase (1990-1995) is characterized by heavy hiring of outside support personnel and/or a drain on the existing organization with a back fill operation for replenishing the organizations that are depleted. LRB processing personnel build-up does not make an impact until 1994

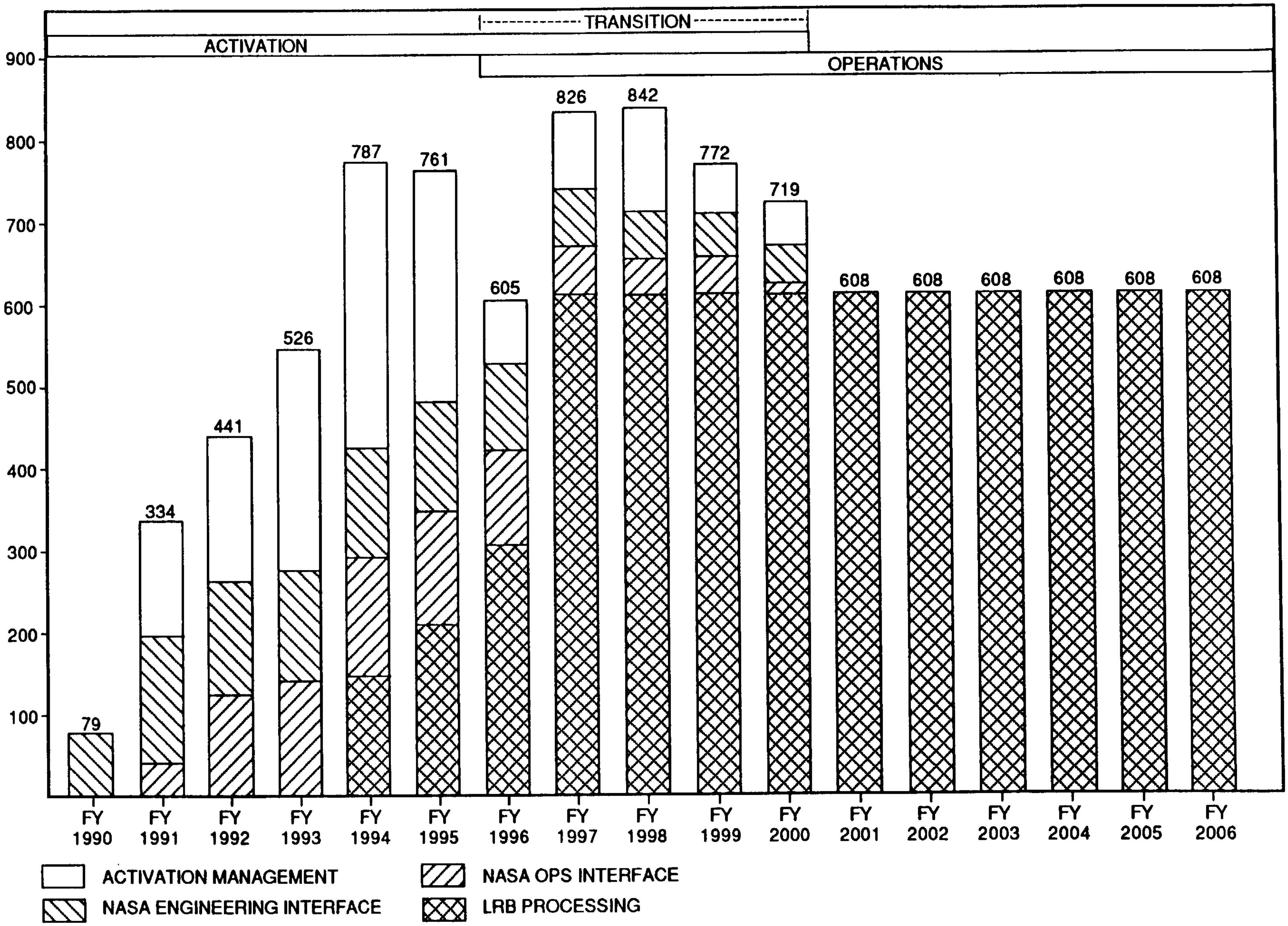


Figure 6.4-1. Cumulative LRB Manpower By Support Phase.

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caused by the need to train and certify technicians for ILC. The decision on whether to go outside versus using existing organization is driven by two requirements; the need for persons with the hands-on facility experience, tempered by the requirement to minimize the impact on the on-going SRB operation. The best solution is probably a combination inside/outside approach with the ability to absorb key personnel back into the operating organization during the Operational phase.

The Transitional Phase (1996-2000) has the peak headcount for the program with maximum demands on all teams to complete remaining facilities, provide IOC, increase LRB rates up to 14 launches per year, and down size the SRB program to a standby facility status. Decisions will also need to be made on retaining a portion of the remaining team members, as well as what to do with the SRB personnel that have not been absorbed into the LRB operation.

The Operational phase (2001 - 2006) is characterized by minimum support requirements from the various teams. Most of the teams have been reduced or infused into the operational team. An ongoing requirement for training and certification should be accommodated within the operational organization. Based on new technology and operational experience of the previous ten years, there should be some favorable reduction in manpower as the operational phase continues. These have not been projected into the operational phase since they would be difficult to quantify. These should be the subject of ongoing studies.

6.5 TRAINING

The introduction of LRB technology plus the large number of new personnel to support the program will have a significant impact on the training department. They will still have to keep up the certifications and training requirements for the SRB operation until they are phased out in FY 2000.

Training requirements would be impacted by the following factors:

- LRB Technology
    - RP-1 handling and storage (new)
    - Horizontal Processing Facility
    - Modifications to VAB/Pads
    - LRB MLPs
    - Electric TVC/battery handling

- Personnel (new)
  - Walkdowns
  - Safety
  - Hazardous operation
  - Security
  - Standboards
  - Certifications

- Personnel (cross-over)
  - Walkdowns
  - Hazardous Operations
  - Standboards
  - Certifications

While there are currently 45 persons in the training operation it is difficult to assess what portions are involved with the "training" of the SRB personnel. Hardware specifications and processing tasks will be needed to quantify the impact and whether some additional personnel would be required to meet the new requirements.

Figure 6.5-1 is designed to show the year and magnitude with which impact occurs but has non-dimensional parameters because of the difficulty in assigning numbers. Further refinement and definition of manpower should be part of the next phase of this study.

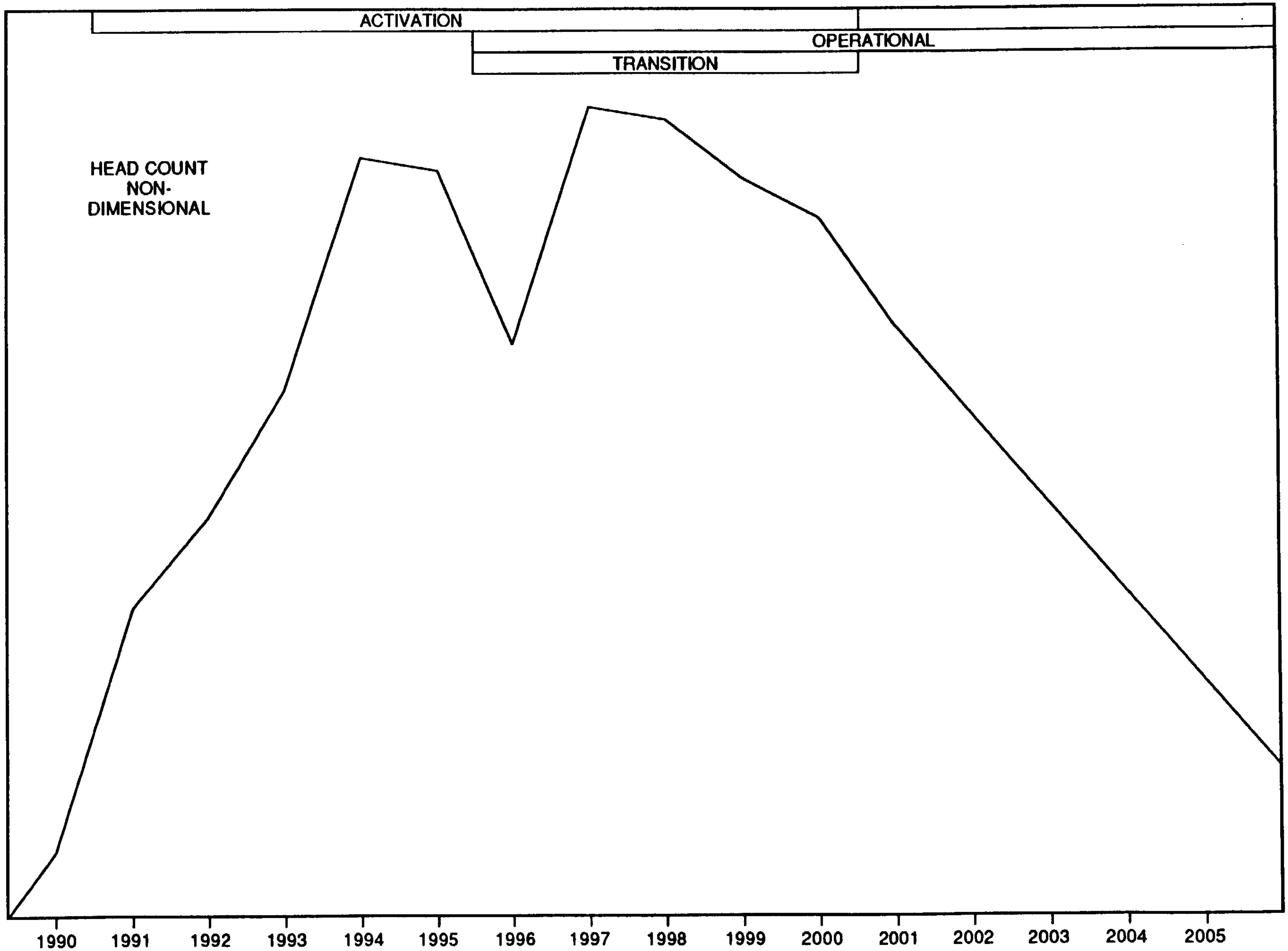


Figure 6.5-1. Training Requirements Impact By Year.

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VOLUME III

SECTION 7

COST ESTIMATES INCLUDING TRANSITION

VOLUME III SECTION 7

COST ESTIMATES

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COST ESTIMATES

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VOLUME III SECTION 7

COST ESTIMATES AND TRANSITIONS

This section consists of summary level Rough Order of Magnitude (ROM) non-recurring cost estimates for each station set impacted by integration of Liquid Rocket Boosters (LRB) into the Space Transportation System (STS) at the launch site. It documents the Phase A cost estimating approach, including a discussion on the cost methodology, and the ground rules and assumptions. The process utilized in developing element costs for design, termination/test/verification, initial spares and activation management is also discussed.

7.1 COST ESTIMATING APPROACH

A bottoms-up approach was used in developing the cost estimates presented in this section. These costs are summarized from the detailed engineering estimates contained in Volume V, Appendix 7 of this report. This detailed estimating process has been limited to the non-recurring facility costs at the launch site. Recurring costs are documented in Volume II, Section 2 and Volume III, Sections 6 and 11.

Cost estimates have been prepared for each station set impacted by LRB integration, and are based upon the engineering concepts documented in Volume III, Sections 3,4, and 5 of this report. Facility requirements, Launch Support Equipment (LSE) and Ground Support Equipment (GSE) impacts have been identified and costed as unique elements.

The LO2/RP-1 pump-fed configuration was utilized as a baseline for estimate. Alternate vehicle configurations were addressed, and significant delta impacts have been priced.

All costs are Rough Order of Magnitude (ROM) and intended for budgetary and planning purposes only.

7.1.1 Cost Methodology

Three estimating methods were used extensively in development of the LRB station set non-recurring costs.

Historical comparisons were made to similar facilities, systems and equipment at Kennedy Space Center (KSC) and uniquely applied to the proposed LRB engineering concepts. Actual government estimates were utilized, and escalation factors incorporated. Costs for the new LRB MLP's and the LETF were developed with this method.

A number of current data sources have been referenced for line item costing. These sources include estimating trade manuals published by R. S. Means Company and Frank R. Walker Company. Government estimating documents were also referenced, including TR-1508 "Budget Cost Data For Facilities Construction And GSE Elements" and TR-1511 "KSC Monthly Facility Construction and GSE Cost Index". Costs for the Pad flame deflectors and the High Voltage Power System were developed with this method.

Vendors were contacted for budget quotes when historical data, current trade manuals and government publications were determined as insufficient. Costs for the propellant spheres and dewars were developed with this method.

7.1.2 Ground Rules And Assumptions

The following list of ground rules and assumptions were adhered to in completing the LRB non-recurring cost estimates:

A. The LO2/RP-1 pump-fed configuration is the selected baseline for all estimates.

B. Cost estimates are Rough Order of Magnitude (ROM)

C. Costs are estimated in constant fiscal year 1987 dollars

D. Cost estimates include the equivalent of a 40% government wrap factor.

E. A discount rate has been excluded

F. SRB de-activation costs have been excluded

G. Direct unit costs include labor and material

H. Labor costs include a standard 34% burden for payroll taxes, and insurance (PT&I)

I. Direct cost burdens include sub-contractor overhead @ 15%, sub-contractor profit @ 10%, prime contractor markup @ 10%, bond @ 1% and contingency @ 15%

J. An escalation factor is applied at 5% per year to the mid-point of implementation

K. Escalation is based upon the current station set implementation schedules shown in Volume III, Section 1 of this report.

7.1.3 Design

Design costs have been derived based upon industry accepted percentages of the total facility, LSE and GSE costs.

Station sets defined as first line facilities include costs for a Preliminary Engineering Report (PER), factored at 1%. PER costs are excluded for the design/build concept of implementation.

A typical factor of 8% has been utilized for the design services. A reduced factor of 6% has been applied for the 2nd. MLP and 2nd Pad designs based upon a near-identical configuration with the first line facilities.

Supervision, Inspection and Engineering Services (SIES) has been treated as a design cost element. It is intended to procure this service as part of each A & E contract. A factor of 10% has been applied.

7.1.4 Termination/Test/Verification (TTV)

Implementation plans for both pads and new LRB MLPs include the concept for utilization of a TTV type contract. A historical comparison was made with the TTV contract experience on LC-39 Pad B and MLP-3. Costs were developed based upon an expected LRB manpower level, contract duration and fully loaded manhour rate.

7.1.5 Initial Spares

The approach to initial spares is consistent with the current STS program sparing philosophy. An adequate quantity of initial spares will be provided for the Launch Support Equipment (LSE) and Ground Support Equipment (GSE). Initial spares costs were derived based upon a typical 9% factor of the total LSE and GSE costs at each station set.

7.1.6 Activation Management

Activation of the LRB launch and landing site station sets is a planned ten year program. Our current concept is to manage this program utilizing a joint NASA and contractor community in a centralized management structure. The LRB activation management team has the primary responsibility for funding, design, procurement, implementation and verification at the program and project levels. The costs for this effort were derived utilizing a 15% factor of the total scope of work.

7.2 KSC COST SUMMARY

The LRB station set non-recurring costs have been summarized and are presented in a matrix format. Each matrix breaks the respective station set costs into design, facility requirements, LSE, GSE, TTV, initial spares and activation management. Figure 7.2-1 displays a percentage comparison of these aforementioned cost elements as a function of the total non-recurring costs.

Figures 7.2-2 through 7.2-5 display the cost summary matrixes respectively for the LO2/RP-1 pump-fed, LO2/RP-1 pressure-fed (MCC), LO2/RP-1 pressure-fed (GDSS) and LO2/LH2 pump-fed configurations. There is a negligible difference in the non-recurring cost impact between the MMC and GDSS LO2/RP-1 pump-fed configurations, and are therefore presented in one figure.

7.3 STATION SET ESTIMATES

The detailed engineering estimates, presented in Volume V Appendix 7 of this report, were prepared for the following LRB station sets:

- ET/LRB Horizontal Processing Facility (HPF)
- LRB Engine Shop

- VAB High Bay 4
- VAB High Bay 3
- VAB Crawlerway
- LRB Mobile Launch Platform (MLP) #4
- LRB Mobile Launch Platform (MLP) #5
- MLP Parksite #2
- LC-39 Pad B
- LC-39 Pad A
- Launch Control Center (LCC)
- Launch Equipment Test Facility (LETF)
- High Voltage Power Distribution

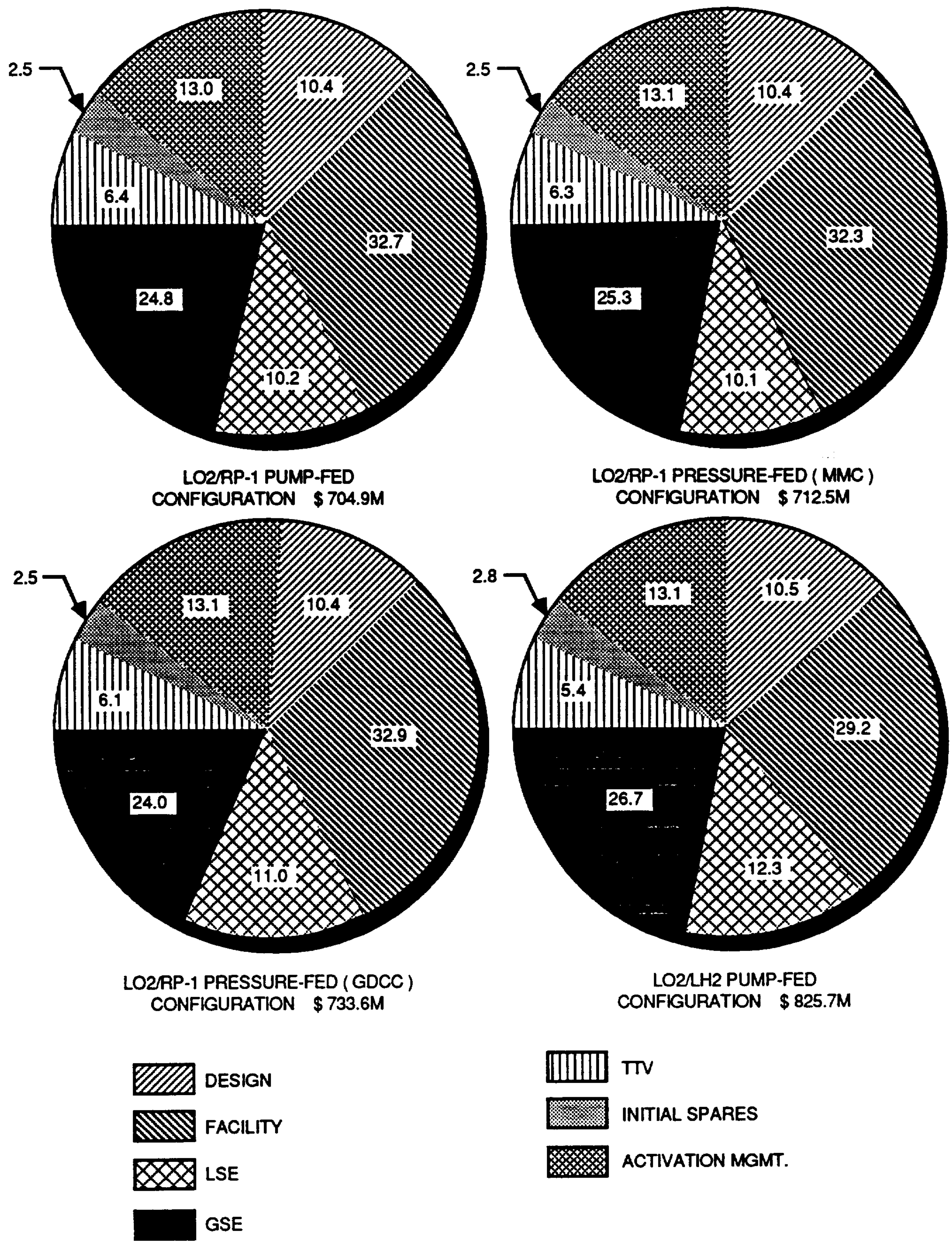


Figure 7.2-1. LRB Non-Recurring Costs- Elements Comparison

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STATION SET	DESIGN	FACILITY	LSE	GSE	TTV	INITIAL SPARES	ACTIVATION MGMT	TOTAL
LRB/ET PROCESSING	9.9	46.4	-	15.6	-	1.4	11.0	84.3
LRB ENGINE SHOP	-	-	-	26.6	-	2.4	4.4	33.4
VAB HIGH BAY 4	4.1	20.0	-	1.6	-	0.2	3.9	29.8
VAB HIGH BAY 3	1.4	7.5	-	1.2	-	0.1	1.5	11.7
VAB CRAWLERWAY	0.8	4.3	-	-	-	-	0.8	5.9
LRB MLP #4	20.9	51.9	22.9	35.3	17.9	4.4	22.9	176.2
LRB MLP #5	13.9	51.9	13.1	22.0	17.9	1.9	18.1	138.8
MLP PARKSITE #2	0.4	2.2	-	-	-	-	0.4	3.0
LC-39 PAD B	10.0	14.5	1.8	36.4	4.6	3.5	10.6	81.4
LC-39 PAD A	8.4	14.5	1.8	36.4	4.6	3.5	10.4	79.6
LCC	0.3	1.7	12.3	-	-	-	2.2	16.5
LETF	-	-	20.1	-	-	-	3.0	23.1
HIGH VOLTAGE POWER DIST.	2.9	15.5	-	-	-	-	2.8	21.2
TOTAL	73.0	230.4	72.0	175.1	45.0	17.4	92.0	704.9

($ IN MILLIONS)

Figure 7.2-2. LRB Non-Recurring Costs Summary Matrix
LO2/RP-1 Pump-Fed Configuration

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STATION SET	DESIGN	FACILITY	LSE	GSE	TTV	INITIAL SPARES	ACTIVATION MGMT	TOTAL
LRB/ET PROCESSING	9.9	46.4	-	15.6	-	1.4	11.0	84.3
LRB ENGINE SHOP	-	-	-	26.6	-	2.4	4.4	33.4
VAB HIGH BAY 4	4.1	20.0	-	1.6	-	0.2	3.9	29.8
VAB HIGH BAY 3	1.4	7.5	-	1.2	-	0.1	1.5	11.7
VAB CRAWLERWAY	0.8	4.3	-	-	-	-	0.8	5.9
LRB MLP #4	20.9	51.9	22.9	35.3	17.9	4.4	22.9	176.2
LRB MLP #5	13.9	51.9	13.1	22.0	17.9	1.9	18.1	138.8
MLP PARKSITE #2	0.4	2.2	-	-	-	-	0.4	3.0
LC-39 PAD B	10.5	14.5	1.8	39.0	4.6	3.7	11.1	85.2
LC-39 PAD A	8.9	14.5	1.8	39.0	4.6	3.7	10.9	83.4
LCC	0.3	1.7	12.3	-	-	-	2.2	16.5
LETF	-	-	20.1	-	-	-	3.0	23.1
HIGH VOLTAGE POWER DIST.	2.9	15.5	-	-	-	-	2.8	21.2
TOTAL	74.0	230.4	72.0	180.3	45.0	17.8	93.0	712.5

($ IN MILLIONS)

Figure 7.2-3. LRB Non-Recurring Costs Summary Matrix
LO2/RP-1 Pressure-Fed (MMC) Configuration

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STATION SET	DESIGN	FACILITY	LSE	GSE	TTV	INITIAL SPARES	ACTIVATION MGMT	TOTAL
LRB/ET PROCESSING	10.6	50.8	-	15.6	-	1.4	11.8	90.2
LRB ENGINE SHOP	-	-	-	26.6	-	2.4	4.4	33.4
VAB HIGH BAY 4	4.6	22.6	-	1.6	-	0.2	4.4	33.4
VAB HIGH BAY 3	1.4	7.5	-	1.2	-	0.1	1.5	11.7
VAB CRAWLERWAY	0.8	4.3	-	-	-	-	0.8	5.9
LRB MLP #4	20.9	51.9	22.9	35.3	17.9	4.4	22.9	176.2
LRB MLP #5	13.9	51.9	13.1	22.0	17.9	1.9	18.1	138.8
MLP PARKSITE #2	0.4	2.2	-	-	-	-	0.4	3.0
LC-39 PAD B	11.1	16.5	5.0	36.9	4.6	3.8	11.7	89.6
LC-39 PAD A	9.4	16.5	5.0	36.9	4.6	3.8	11.4	87.6
LCC	0.3	1.7	12.3	-	-	-	2.2	16.5
LETF	-	-	22.7	-	-	-	3.4	26.1
HIGH VOLTAGE POWER DIST.	2.9	15.5	-	-	-	-	2.8	21.2
TOTAL	76.3	241.4	81.0	176.1	45.0	18.0	95.8	733.6

($ IN MILLIONS)

Figure 7.2-4. LRB Non-Recurring Costs Summary Matrix
LO2/RP-1 Pressure-Fed (GDSS) Configuration

STATION SET	DESIGN	FACILITY	LSE	GSE	TTV	INITIAL SPARES	ACTIVATION MGMT	TOTAL
LRB/ET PROCESSING	10.6	50.8	-	15.6	-	1.4	11.8	90.2
LRB ENGINE SHOP	-	-	-	26.6	-	2.4	4.4	33.4
VAB HIGH BAY 4	4.6	22.6	-	1.6	-	0.2	4.4	33.4
VAB HIGH BAY 3	1.4	7.5	-	1.2	-	0.1	1.5	11.7
VAB CRAWLERWAY	0.8	4.3	-	-	-	-	0.8	5.9
LRB MLP #4	22.9	51.9	30.0	38.5	17.9	5.3	25.0	191.5
LRB MLP #5	15.6	51.9	20.2	25.2	17.9	2.9	20.1	153.8
MLP PARKSITE #2	0.4	2.2	-	-	-	-	0.4	3.0
LC-39 PAD B	14.7	16.5	5.0	55.7	4.6	5.4	15.3	117.2
LC-39 PAD A	12.4	16.5	5.0	55.7	4.6	5.4	14.9	114.5
LCC	0.3	1.7	12.3	-	-	-	2.2	16.5
LETF	-	-	29.0	-	-	-	4.4	33.4
HIGH VOLTAGE POWER DIST.	2.9	15.5	-	-	-	-	2.8	21.2
TOTAL	86.6	241.4	101.5	220.1	45.0	23.1	108.0	825.7

($ IN MILLIONS)

Figure 7.2-5. LRB Non-Recurring Costs Summary Matrix
LO2/LH2 Pump-Fed Configuration

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13. ABSTRACT *(Maximum 200 words)*

The impacts of introducing Liquid Rocket Boosters (LRB) into the STS/KSC Launch environment are identified and evaluated. Proposed ground systems configurations are presented along with a launch site requirements summary. Pre-launch processing scenarios are described and the required facility modifications and new facility requirements are analyzed. Flight vehicle design recommedations to enhance launch processing are discussed. Processing approaches to integrate LRB with existing STS launch operations are evaluated. The key features and significance of launch site transition to a new STS configuration in parallel with on-going launch activities are enumerated.

The LRB Integration Study Final Report is presented in Five volumes as follows:

VOL I Executive Summary
VOL II Study Summary
VOL III Study Products
VOL IV Reviews and Presentations
VOL V Appendices

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